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TABLE OF CONTENTS.

ENGINEERING NEWS OF THE WEEK.....17, 29, 30
The New Water Supply System of Rockford, Ill. (illustrated).... 18
The Largest Dipper Dredge Ever Built (with full-page plate) 19
Relief Map Construction 21
The Hollow Walls or Inspection Chambers of the Charonne Reservoir, Paris (illustrated)..... 21
English Experience with Garbage as Fuel for Electric Light Stations 21
The Theoretical Treatment of Air-Cooling Water Towers (illustrated)..... 22
American Locomotives for Finland (illustrated)... 23
Corrugated Firebox Sheets for Locomotive Boilers (illustrated)..... 23
The Gruson Chilled Cast-Iron Rotating Turret for Coast Fortifications (illustrated)..... 27
A Sewage Distributing Tank and Automatic Dosing Apparatus at Marion, Ia. (illustrated)..... 27
Results of Tests of Mechanical Filters at East Providence, R. I..... 29
Standards for Electrical Apparatus 30
EDITORIAL NOTES 24
The Irish Channel Tunnel Scheme—Railways for Water Transportation and Canals for Land Transportation—The Influence of Water Filtration and of Sewage Disposal on the Curtailment of Water Waste—Geological Studies in Connection with Engineering Works.
EDITORIAL:
The Real Advantages of Electric Motive Power.... 24
LETTERS TO THE EDITOR 25
The Philadelphia Excursions Following the American Society of Civil Engineers' Convention—Water Pollution Studies in England and the United States (Correction)—A New Test for Slag Cement—Adulteration of Portland Cement—An Instance of Rail Damage by Slipping Driving Wheels—Test of a 14-in. Riveted Steel Main at New Westminster, B. C.—Strength of Wooden Floor Beams—The Use of Wheel Concentrations in Computing Bridge Stresses—Random Notes Abroad—Notes and Queries.

THE ISTHMIAN CANAL COMMISSION'S plans for its work are described as follows in a press dispatch from Washington, dated July 8:

The Isthmian Canal Commission has finished its present session in Washington, and the members have gone to their homes to wind up their personal or professional business before starting for the field. It has been settled that the field force taken from this country will number about 75 all told, in addition to whatever local help may be picked up on the Isthmus.

The first party to leave this country will consist of Admiral Walker, Colonel Ernst, Mr. Burr and Mr. Morrison, constituting the Panama Committee, with probably two other members of the Commission, who will start in about 30 days for Paris. There they will examine the records of the Panama company and secure whatever information is obtainable in connection with that part of the work. It is possible they may visit Kiel before returning.

The remainder of the Commission in this country will do whatever is possible, by correspondence with the Central American Governments, who may be interested in the route to be finally selected.

The start of the entire Commission for the Isthmus will probably be made in November. When the Commission takes the field it will divide into three sections, one to study the Panama route, one to investigate the Nicaragua route, and the other to go over the Darien line. Afterward the San Blas and several minor routes will be studied so as to leave no question open when the survey is finished.

THE CHICAGO DRAINAGE CANAL is to be opened in December next, if possible, and the Trustees are spurring the contractors on to greater activity in order to ensure that this is done. Extra prices are to be paid to certain contractors who will guarantee the completion of their work by Dec. 1, as this will necessitate the employment of additional men to carry the work on night and day. Some of the contractors, however, are very far behindhand with their work, and these are being threatened with a cancellation of their contracts. The desire is to have the channel completed and opened before Congress meets, and thus to avoid the opposition that will be made at the next session. Gen. Alger's permit for opening the canal will expire when Congress opens.

THE OPENING OF THE SOULANGES CANAL to traffic will take place in August, according to the present plans of the Canadian Government Engineers. As is quite well known, the Soulanges Canal is the last of the series of short canals along the Canadian side of the St. Lawrence River, by which a 14-ft. waterway will be obtained from the Great Lakes to the Ocean. From Lake Ontario to Montreal the fall in the river is 221 ft. This fall is not gradual, but is made up of a series of rapids, which, while they are passable down stream by boats of adapted construction, are not satisfactory for commercial purposes. The canals are built at those points in the river where the rapids occur, tapping the river above the rapid and debouching again into it below the rapid. All of these canals, with their locks, are of the same capacity as the Welland canal, which was enlarged in 1884 to a depth of 14 ft., with locks 270 ft. long and 45 ft. wide. The Soulanges canal, just now completing, is on the north side of the river, near Montreal, and will, when finished, take the place of a shallow canal on the south side that was formerly used. It is 14 miles long and has five locks.

A CANAL CONNECTING THE WISCONSIN LAKES in the Waukesha county resort region is proposed. According to the present plans the lakes to be connected are La Belle, Fowler, Oconomowoc, Upper and Lower Nashota and Upper and Lower Nemahbin. Between La Belle and Fowler lakes, where the distance is short and the fall is 9 ft., a boat railway will be built, but the links connecting the other lakes will be canal with masonry locks. It is stated that the surveys have been made and all the plans completed and that work will begin soon on the construction, which will cost about $35,000.

THE FLOW OF WATER OVER WEIRS of different shapes has been investigated at the new Cornell hydraulic experiment station for the U. S. Deep Waterways Commission. Mr. Geo. W. Rafter, M. Am. Soc. C. E., represented the commission. The experiments will supplement those of Bazin, carried on for many years in France, the results at Cornell being for higher weirs than those used by either Bazin or Francis. The Cornell hydraulic laboratory was described in our issue of March 2, 1899. Mr. Gardner S. Williams, Assoc. M. Am. Soc. C. E., Professor of Experimental Engineering, is in direct charge of the laboratory, and Prof. E. A. Fuertes, M. Am. Soc. C. E., is Director of the College of Civil Engineering of Cornell University.

THE WATER POWER OF THE PLATTE RIVER is to be developed by means of a plant at Fremont, Neb., 35 miles from Omaha, which latter city will be supplied with electric current for lighting and power purposes. Dams will be built in the river at Fremont and 27 miles above, and a canal will be built between these dams. It will have a capacity of 4,000 cu. ft. per minute, and the fall at the power station will be about 150 ft. A reservoir of 5,000,000,000 gallons capacity will supply the canal. It is estimated that 7,200 HP. can be delivered at the Omaha substation, calculated on a 24-hour basis, or 2,500 HP., if calculated on a 10-hour basis.

HARBOR IMPROVEMENTS are to be carried out at Montevideo, Uruguay, at a cost of $15,000,000, to $20,000,000. The Minister of Public Works has approved the plans and specifications, and has matured a scheme for the provision of the necessary funds. Mr. Finch, the U. S. Minister at Montevideo, and Mr. Howard, the U. S. Vice-Consul, report that the project offers a good opportunity for American contractors.

THE NEW TUNNEL PROJECTS FOR GREATER NEW York have now reached a total number of six, not including the long-talked-of rapid transit railway tunnel lengthwise of Manhattan Island. Assuming the estimates of the projectors to be correct, the total cost of these six tunnels will reach $33,000,000. The various projects are as follows: The Hudson River Tunnel Co., for a structure from 15th St., Jersey City, to near the foot of Morton St. in Manhattan, the total cost of which will be more than $6,000,000, of which $4,000,000 has been expended; the Manhattan Tunnel Railway Co., from Chambers St. and West Broadway to some point in Jersey City not named, to cost $5,500,000; the Manhattan & Jersey City Tunnel Co., no terminals announced, but it is said the work will cost $5,000,000; the New York & Long Island Terminal Co., connected with the Long Island R. R., for a tunnel from the Flatbush Ave. station of the Long Island R. R. in Brooklyn to some point in Cortlandt St., Manhattan, between Broadway and West St.; the company was recently incorporated, with a capital of $7,500,000; the New York & Brooklyn Railway Co., which is planned to connect the Ctiy Halls of the two boroughs, at a cost of not less than $5,000,000, and it may be much more; and a company represented by Edward Lauterbach, concerning which nothing is known except that it plans to connect the two boroughs. The three tunnels first named are to be under the North River and the other three under the East River. Except the tunnel extension of the Long Island R. R., which was fully described in Engineering News of May 18, 1899, none of these projects is on a basis which promises that its construction will be undertaken very soon.

THE EAST BOSTON TUNNEL SCHEME, proposed by the Boston Transit Commission as an extension of the subway system, has been declared illegal by the State Supreme Court. The ground for the decision was that the tunnel, as proposed, would not actually connect with the present subway at grade, but would leave a gap of some 1,200 or 1,500 ft. of surface railway. One of the principal reasons for not making the tunnel connect was that the appropriation for the work was found to be insufficient.

MUNICIPAL OWNERSHIP OF STREET RAILWAYS at Detroit, under the plan proposed, has been declared unconstitutional by the State Supreme Court. The court says that the constitution prohibits the making of internal improvements by the State and that the State cannot authorize a municipality to do what the State cannot do. It classes street railways as internal improvements, which, under the above ruling, are unconstitutional.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was a rear collision at Newman, Cal., on the Southern Pacific Ry., July 10. A special train of ten cars, taking teachers to the National Education Association Convention at Los Angeles, ran into a freight train which was taking water. The tender of the passenger train telescoped the first sleeping car, killing two persons and injuring 13 others.

ATTEMPTS AT TRAIN WRECKING have been made in four different cases on eastern roads during the past week. On the New York, New Haven & Hartford R. R. boys wedged an iron bar across the rails at Westchester, N. Y., July 6, and the obstruction was only discovered and removed by the trackmen just before the Washington express passed.——At Blackwells, Pa., on July 4, a blocked frog derailed the engine of an excursion train on the Falls Brook R. R., and the train narrowly escaped going over a high embankment.——At Shamokin, Pa., boys tampered with a switch and its signal in an attempt to derail a passenger train on the Herndon branch of the Philadelphia & Reading R. R.——On July 9, spikes and stones were placed upon the rails of the Mount Penn Gravity Railway, near Reading, Pa., but the obstructions were discovered and removed.——With the exception of the case at Blackwells, the wreckers were captured.

THE WRECK OF THE S. S. "PORTIA," of the Red Cross Line, occurred July 10, at Sambro Island, 14 miles southwest of Halifax, N. S. The steamer was making a trip from New York to Halifax, and ran on the rocks during a heavy fog about 7 p. m. There were many passengers on board, mainly tourists for Nova Scotia, but all were got ashore safely in the boats. It is reported that the vessel sank very soon after, being broken up by its pounding on the rocks.

FLOODS IN TEXAS, caused by the overflow of the Brazos and Colorado rivers, have caused an immense amount of damage, and considerable loss of life. In fact, the floods are said to be the worst ever experienced in that state, although the valleys of these rivers are annually subject to overflow.

THE LOSS OF THE STEAMER "PARIS" is now admitted to have been due to the error of her captain, Frederick Watkins. In his official statement Captain Watkins says:

I was master of the steamship "Paris" when she left Southampton at noon on the 20th of May last, with passengers, mails and general cargo, bound for New York via Cherbourg and at 5.31 o'clock p. m. of the same day she arrived at Cherbourg. Having taken on board 45 further passengers and their baggage, we sailed for New York at 5.52 p. m. At 6.38 p. m. Cape La Hogue was abeam, and at 7.35 p. m. the Casquets Lighthouse was abeam. At 1.19 a. m. of the 21st of May land was suddenly seen ahead and reported. The helm was immediately put hard to starboard, and the port engine was put full speed astern, but directly afterward the vessel struck on the rocks, which proved to be about a cable's length from the beach.

I regret to say that the casualty was owing to an unaccountable error on my part. It is about 131 miles from Cape La Hogue to the Lizard, and the run between these points would, I calculate, occupy 6 h. and 54 min. Unfortunately I reckoned the time on this basis for coming up with the Lizard from 7.35 p. m., when abeam of the Casquets instead of from 6.38 p. m., when abeam of Cape La Hogue, and the vessel was thus really 18 miles ahead of the position I was acting upon. In addition the thick weather over the land had obscured the Lizard lights.

I attribute the stranding to the above cause, and take upon myself full responsibility for it.

The local board of steamship inspectors criticise Capt. Watkins' statement in that it makes no mention of the fact that the vessel at the time of the disaster was some seven miles north of her true course, supposing the intention to have been to pass the Lizard at a distance of three miles. The report then continues:

As Captain Watkins does not make any mention of making any allowance for tide, we are of the opinion that he had not taken that matter into consideration, whereas when he approached the English coast he must have encountered the flood tide on his port bow, setting him in toward the land. In addition to this he makes no mention of having used his lead, and he only discovers it was thick over land when the ship was ashore.

In view of these facts the inspectors have suspended Capt. Watkins' license for two years. The steamer was successfully pulled off the rocks on July 11 by the German wrecking firm which undertook the work after the steamship company had abandoned the vessel to the underwriters.

THE SHIPBUILDING WORKS of the New York Shipbuilding Co., at Camden, N. J., will be among the largest and the most fully equipped in the world, according to reports of the company's plans. Work is now in progress on the 800-ft. dry-dock and on the foundations of the buildings. The site has an area of 120 acres, with a frontage of 3,500 ft. on the Delaware River, and 40 ft. of water at low tide along the frontage. Mr. Henry G. Morse, formerly of the Harlan & Hollingsworth Co., is President; and Capt. Randle, formerly of the American Line, is General Superintendent.

PROTECTIVE DECKS of 2-in. nickel steel plate are to be used on the six new cruisers for the U. S. Navy. This will involve the widening of the ships about 12 ins. and will add about $16,000 to the cost of construction of each ship.

THE NEW WATER SUPPLY SYSTEM OF ROCKFORD, ILL.

The original water supply system of the city of Rockford, Ill., was put in during 1874-75, the city then having a population of about 12,000. It was mainly intended for fire protection, the domestic supply being a secondary consideration. The pumping plant, however, was not well located, and as the supply was drawn from Rock River, above the existing dam, there was soon trouble from the muddy and unwholesome quality of the water. In 1879, a council committee visited a number of cities to investigate the various methods of securing water, and finally recommended the sinking of a large well into the porous strata of gravel underlying the northwest portion of the city, and the use of the water so secured. At an expense of probably about $20,000 the large well south of the present pumping works was constructed; but when the city began to utilize this source of supply, it was found that the well, while not drawing water from the river, drew it from a still more contaminated source, namely, from under the city itself, and the wells and cesspools for a radius of more than 2,000 ft. were drawn upon for the supply to the city well. This project, while undertaken in good faith, and with the best intentions, was carried out without adequate engineering advice, and the result was an expensive failure.

The city then returned to the use of river water, which remained the source of supply until about 1885, when the first artesian well was drilled. Before attempting to bore for artesian water, Mr. T. C. Chamberlain, of the U. S. Geological Survey, and formerly state geologist of Wisconsin, who was, perhaps, the best-informed man on the artesian wells of the upper Mississippi valley, was retained to report to the city on the subject. By his advice, a trial well was dug, which is the present well No. 1, and flowing artesian water was encountered, but with somewhat less head than had been predicted by Mr. Chamberlain. This well was followed at various times by the sinking of four more wells, until 1890, when the number of wells then sunk into the Potsdam strata had reduced the head, so that the amount of water obtained by new wells was not thought to be in proportion to the amount of money expended in their construction.

More water was needed, and in 1891 Mayor Starr and the council decided to call in professional advice. Mr. J. T. Fanning, M. Am. Soc. C. E., was secured as chairman of a commission of engineers, the other members of which were Mr. D. C. Dunlap, M. Am. Soc. C. E. (then city engineer), and Mr. Daniel W. Mead, M. Am. Soc. C. E. (who had been associated with Mr. Chamberlain in his investigations, noted above). The commission examined the question of water supply very carefully, and reported on eight different methods of securing an additional supply. The method which the commission strongly recommended for adoption involved the sinking of a shaft about 80 ft. into the clay underlying the city, and the drilling of wells at the base of this shaft into the St. Peter and Potsdam sandstones. This system is essentially the same in general outline as the plan recently carried into effect by Mr. Mead. The investigation of this commission involved considerable expense to the city, but the recommendations of the report were not utilized. For financial reasons it was considered by some of the aldermen inexpedient to undertake the construction of the works recommended at that time, and the only move in that direction was the boring of four wells into the St. Peter sandstone.

During the summer of 1892 an increased demand for water required that something be done at once to increase the supply, and as a temporary expedient, several of the American Well Works Co.'s direct-acting steam deep-well pumps were purchased and placed in the St. Peter wells at considerable expense. This tided the city over the two seasons of 1892 and 1893, but the capacity of the pumps was soon reached, and even with the capacity obtained, the expense of pumping was increased on an average of over $2 per 1,000,000 gallons, or from $8.38 in 1891 to $10.90 in 1893. It was soon seen that these deep-well pumps were inadequate and exceedingly expensive in operation.

About this time the features of the Pohle air-lift pump were presented to the council, and as immediate action was necessary, a plant was purchased and erected at an expense of about $12,000. The extra water was procured, but at considerable extra cost; the total cost per million gallons being, in 1894, $12.53, and in 1895, $11.52, or over $3 per million gallons more than in 1891. Even with the Pohle air-lift pump in full operation, it was impossible to keep out the river water where a long dry spell was followed by a heavy fire. Both the deep-well pumps and the Pohle air-lift were regarded as only temporary expedients to tide the city over until something better could be devised and installed. As permanent plants they were considered practically failures.

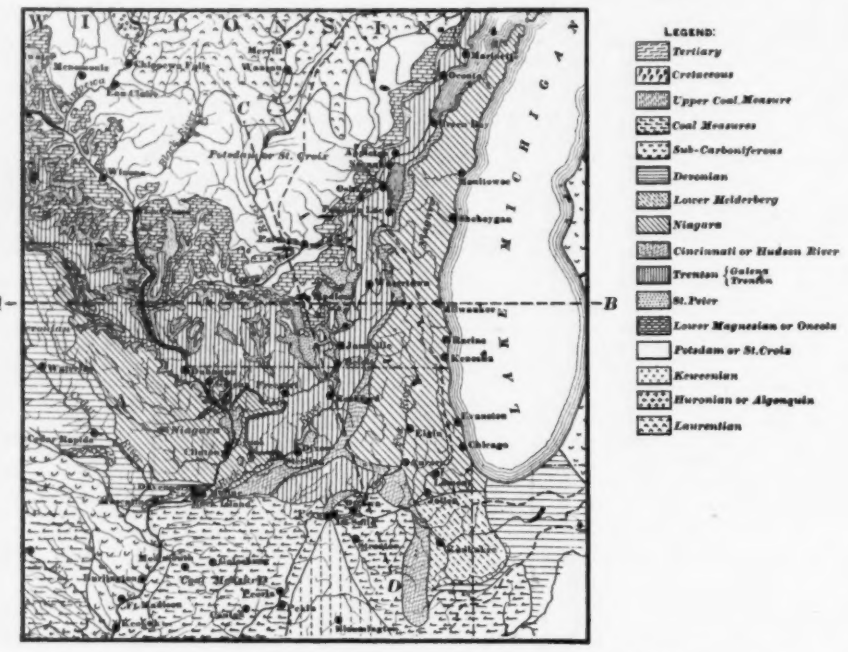


FIG. 1.—MAP SHOWING GEOLOGICAL CONDITIONS AROUND ROCKFORD, ILL.

The cost of pumping was $28.35 per million gallons in 1878, and decreased steadily until 1890 and 1891, when it was $8.37 and $8.38, respectively. With the introduction of the deep-well pumps and air-lift plant the cost increased again, reaching $12.53 in 1894, and $11.52 in 1895, the amount pumped during the latter year being over 1,000,000,000 gallons. While it would have been practicable to have increased the capacity of the air-lift system, it would have necessitated considerably increased cost, especially as a new compressor would have been needed. Estimates based upon the supply needed and the cost of pumping showed that with the amount pumped during 1895, a saving of $1 or $3.50 per million gallons, or $1,000 and $3,500 per year, respectively, would represent 5% interest on capitalized values of $20,000 and $70,000. These latter amounts, therefore, the city could afford to pay in order to reduce the cost of pumping, and secure a more efficient plant.

In 1896 there was again an urgent demand for more water, and correspondence was opened with various engineers in an attempt to secure some new and more efficient plan. Messrs. Johnson & Harrison, of Chicago, made a proposition to put in a plant similar to that at Memphis, consisting of artesian wells and underground collecting galleries or tunnels, for $151,000, guaranteeing a supply of 8,000,000 gallons per day, but the city had reached the limit of its bonded indebtedness, and there was no way of raising the necessary funds.

In August, 1896, Mr. Daniel W. Mead, M. Am. Soc. C. E., of Rockford, Ill., made a proposition to the city to develop a supply of artesian water of 5,000,000 gallons per day. His plan was to sink a shaft into the stratum of clay below the sand and gravel deposits at the existing pumping works, with tunnels from the bottom of the shaft to any or all of the nine existing wells, or to new wells, and to install three pumps of 2,500,000 gallons daily capacity near the bottom of the shaft. This proposition was accepted by the city in January, 1897, the supply of water and capacity of pumping plant being guaranteed. The contract price was $52,000, with an additional amount at the rate of $5,000 per million gallons in excess of the guarantee, but this amount not to exceed the $5,000, which would be for a supply of 6,000,000 gallons per day. The pumping plant was also guaranteed to have a duty of 60,000,000 ft.-lbs., with additions or deductions for duties of 70,000,000 and 55,000,000 ft.-lbs., the latter being the minimum duty permitted.

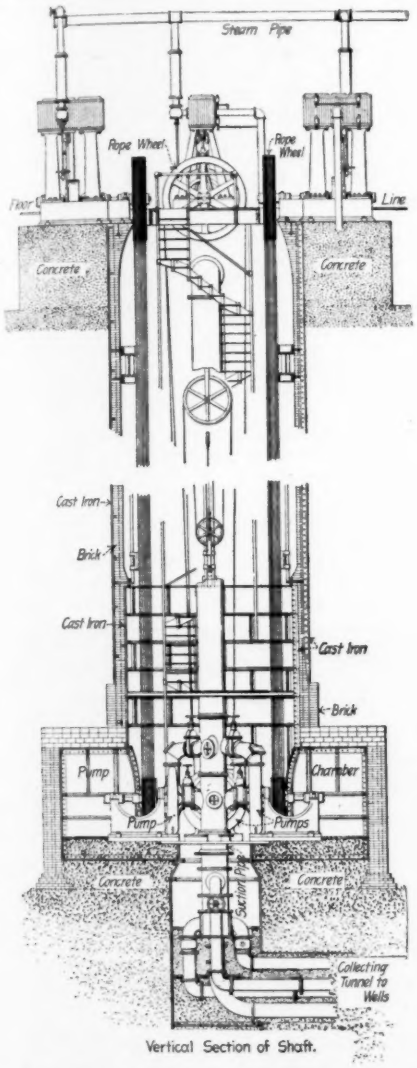
Fig. 1 gives a map and sections of a part of the upper Mississippi Valley, showing the geology in relation to the water supply of Rockford, which is still further shown by the two sections. The white portion of the map in Wisconsin represents the outcropping of the Potsdam or St. Croix sandstone from which most of the water at Rockford is derived. The dotted portions represent the St. Peter sandstone, which lies above the Potsdam and is also water bearing. Through Illinois, at least in the immediate neighborhood of Rockford, it is deeply covered with drift. From this source a portion of the Rockford artesian water is derived.

In a general way, the proposition was essentially as follows: The water from both the St. Peter and Potsdam sandstone formations rose to such a height that a limited quantity of water would flow into the pumping pit. With the Pohle air-lift in use, about 3,000,000 gallons of water could be pumped. In the old plant this water was raised by the air-lift into a pumping pit and reservoir, and from thence was forced into the mains by a Gaskill pumping engine of 6,000,000 gallons capacity. The new plant also raises the water into the pumping pit and reservoir, whence it is pumped as before. Mr. Mead's proposition was to

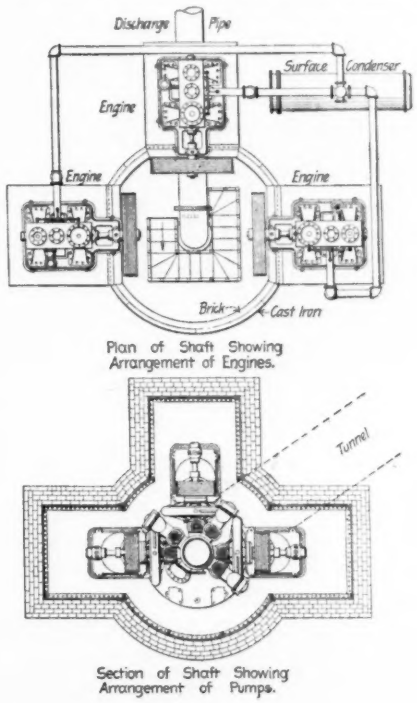
FIG. 1a.—GEOLOGICAL SECTIONS REFERRED TO MAP, FIG. 1.

sink a shaft about 100 ft. in depth, and tunnel out to various wells, placing pumps at the bottom of the shaft, operated by engines at the top. By thus depressing the pumps he expected to be able to increase the volume of water which could be obtained from the wells. This he was able to do, and secured on the first test about 6,500,000 gallons. One of the wells is being reamed out, and it is expected that this will increase the supply to 7,000,000 gallons. The suction pipes of the pumps are connected to three deep wells, averaging in depth about 1,300 ft. each; and five shallow wells (into the St. Peter sandstone) averaging about 400 ft. in depth.

On Jan. 18, 1897, the proposition was accepted



Vertical Section of Shaft.



Plan of Shaft Showing Arrangement of Engines.

Section of Shaft Showing Arrangement of Pumps.

FIG. 2.—SECTIONAL ELEVATION AND PLANS OF THE NEW CENTRIFUGAL PUMPING PLANT FOR THE WATER-WORKS AT ROCKFORD, ILL.

Daniel W. Mead, M. Am. Soc. C. E., Engineer.

and the contract awarded to Mr. Mead, who sublet the contract for the shaft and tunnel to Willard & Cornwell, of Louisville, Ky. The shaft was sunk through 55 ft. of water-bearing sand and gravel into a poor quality of clay. It was built of cast-iron sections, lined with 8 ins. of brick, as shown in Fig. 2, and was sunk under pneumatic pressure. At a depth of 80 ft., the alcoves for the pumps were constructed, after which the air-lock was removed, with the expectation of being able to sink the small shaft and drive the tunnel in open work. While sinking this small shaft, water was encountered at a depth of about 100 ft. below the surface, and the water rose to within about 10 ft. of the surface. The sub-contractors then threw up the contract, claiming that the work could not be done, and Mr. Mead then undertook the execution of the work, the city granting an extension of the time allowed for its completion. In August, 1897, Mr. Mead agreed to drill another artesian well and to increase the supply to 6,000,000 gallons.

A new air-lock was put in, about 30 ft. below the top of the shaft, lowering the water by pumping, and when pressure was applied it was used to blow out the water. Many mishaps were encountered in the construction of the work. It had been expected that the collecting tunnel would be in clay, and of such a character as to hold the water back, but this proved not to be the case. The clay was full of sand seams, and much water was encountered. The last run of tunnel had a clay roof of only about 4 ft., above which was 90 ft. of water-bearing sand and gravel. It was necessary to work for about eight months under pressures varying from 35 to 42 lbs. Three men died from the "bends," or caisson disease. The work of tunneling was completed about May, 1898, and the engines were installed about the first of August. Various delays, however, occurred, so that the plant was not completed and tested until the latter part of December, 1898, although it was pumping water for the city from about the middle of August.

The general design of the plant is shown in Fig. 2. The shaft is 95 ft. deep to the collecting tunnel, and 12½ ft. diameter for a depth of about 80 ft. to the pump chamber, which consists of three horizontal rectangular alcoves or recesses, extending outside the limit of the shaft, and forming three parts of a cross, the length over the long arm of the cross being 25 ft. The chamber is of brick, with an inside iron lining, which extends up the shaft for some distance above the bottom of the outside casing. This chamber has a concrete floor, and in the center is a small shaft, 6 ft. diameter, extending down to the level of the collecting tunnel, which is 5 ft. diameter and about 300 ft. long, with smaller drifts 3 × 4 ft., leading to the wells. When the pipes to the wells had been put in, however, this shaft was filled with concrete to the level of the junction box, forming the base of the suction pipe.

One of the most original and interesting features is the use of centrifugal pumps for such a high lift. Three pumps are used, each driven by a rope transmission system from a vertical inverted engine at the top of the shaft, the ropes being kept taut by a suspended and weighted idler pulley. The engines are of the compound condensing type, with cylinders 9 × 15 ins. and 15⅝ × 15 ins., running at 210 revolutions per minute, maximum speed, under an initial pressure of 85 lbs. at the cylinders. A governor is placed between the cranks. The pump impellers are 3.5 ft. diameter, and are hollow. They are of bronze, cast in sections, and very carefully worked out through the runners, so that the water spaces are all perfectly true and very smooth. The speed of the pumps is from 300 to 350 revolutions per minute for an ordinary supply of 3,000,000 gallons per 24 hours, or 480 revolutions for double that supply for fire purposes. The engine rope driving pulley is 70 ins. diameter, with grooves having an angle of 65°. The pump pulley is 30 ins. diameter, with eight grooves, having an angle of 45°. The pulleys are connected by ¾-in. manila transmission ropes. Steam is supplied by the regular boiler plant of the pumping station, which consists of three return-tubular boilers of 150 HP. each, carrying 100 lbs. pressure. The bottom of the shaft is made easily accessible by a spiral stairway around the discharge pipe.

Fig. 3 is a view of the pumps assembled, before they were placed in the shaft. Fig. 4 is a view of the engines erected in the pumping station, the Worthington surface condenser being in the pit at the right of the view.

The pumps and engines were furnished by the Byron Jackson Machine Co., of San Francisco, Cal. On test, the pumps worked under a 60-ft. discharge head with a suction (measured at the pumps) of 26 ft., making a total lift of 106 ft. They were tested under various loads, and Mr. Mead informs us that they have given extraordinary results. A single engine with its pump has raised over 6,500,000 gallons in a day's test. Under various conditions from the indicated horse-power of the engine to the actual horse-power of water raised, efficiencies of from 65 to 80% have been obtained, the pumps alone giving efficiencies of from 70% to very nearly 75%, the greater efficiencies being on the high lift. These results are believed to be unprecedented in high-lift centrifugal pump work. The capacity and efficiency tests were made by a Board, consisting of Mr. Wm. M. Stowell, M. E., for the city of Rockford; Mr. Byron Jackson, for himself, and by Mr. Mead in his own interests. A duty of 58,000,000 ft.-lbs. per 1,000 lbs. of dry steam was developed. The tests were made in December last, though the plant had been in regular service since August. Mr. W. M. Kimball is Superintendent of Water-Works.

We are indebted to Mr. Mead for particulars, photographs and drawings of the interesting plant above described.

THE LARGEST DIPPER DREDGE EVER BUILT.

(With full-page plate.)

The drawings on our inset sheet illustrate a large dipper dredge recently completed for Hingston & Woods, of Buffalo, N. Y., for use on the Great Lakes. This is claimed to be the largest dredge of its type ever constructed. It has a dipper with a capacity of 8¼ cu. yds., or about 12 tons. While intended for service on the Great Lakes, the dimensions of the hull are such that the dredge can go through the Welland and St. Lawrence canals, and can easily be fitted with tanks for salt water service. The hull and general arrangement of the dredge were planned by Mr. William E. Hingston, and the machinery was designed and built by the Bucyrus Co., of South Milwaukee, Wis. We are indebted to Mr. Hingston and to Mr. A. W. Robinson, M. Am. Soc. C. E., Chief Engineer of the Bucyrus Co., for the information from which this description has been prepared.

Fig. 1 is a general view of the dredge practically ready for work. The hull is built of white oak and Oregon fir, and is 136 ft. long, 42 ft. 3 ins. beam, and 13 ft. 6 ins. deep. There are four longitudinal steel trusses. Two of these are spaced 26 ft. apart, or on the line of the cabin work, and are each 119 ft. long and 25 ft. high. The total height from the keel to the tops of these trusses is 32 ft. The other two trusses are located at the sides, and are each 119 ft. long and 13 ft. deep, or just the depth of the hull. The sides of the hull are 8 ins. thick, and her bow is 12 ins. thick. The bottom and sides are connected by 136 wrought-iron knees. Altogether, including the material in the spuds, there entered into the construction of the hull 157,000 ft. B. M. of fir, 70,000 ft. B. M. of oak, and 23,000 ft. B. M. of pine, or a total of 250,000 ft. B. M. of timber.

There are four spuds, two at the bow, each 4 × 4 ft., made up of four 24 × 24-in. Oregon fir timbers, 50 ft. long, and two at the stern, 2 × 2 ft. in size.

The bow or forward spuds are raised and lowered by power from the main engine by means of wire ropes. There is a large sheave on top of the spud and another fitted in a slot through the spud about 12 ft. from its lower end. There are two ropes to each spud, both connected to opposite ends of one drum, and the ends of the rope are attached to a fixed point outside the spud, and provided with means for adjustment. The rope passing around the sheave near the lower end of the spud serves to raise it, and the other rope passing over the top of the spud serves to force it down with great force and thus "pin up" the dredge.

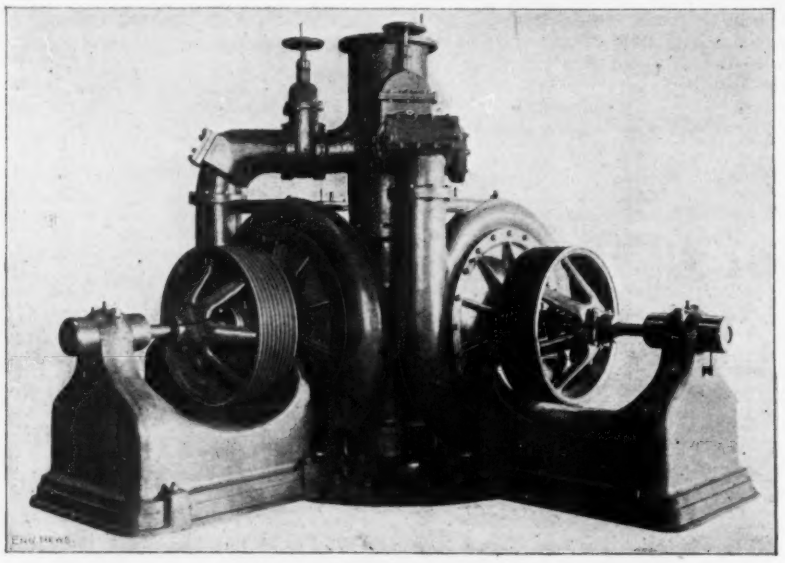


FIG. 3.—CENTRIFUGAL PUMPS DRIVEN BY ROPE TRANSMISSION.
Byron Jackson Machine Co., Builders.

It will easily be seen that with dredges of the dipper type it is very necessary to pin them up securely so that a considerable portion of the weight of the hull at the forward end rests upon the spuds upon the bottom, in order to hold the dredge against the digging thrust of the dipper. The "pinning up" power of the "Pan American" is easily able to lift the end of the hull with all of its machinery upon it 2 ft. in the water, which is equal to sustaining a weight upon the spuds of about 130 tons. When the spuds are off the bottom the hull is "down by the head" several feet, due to the great weight of the machinery on the front end. In other words, no attempt has been made to distribute the weight upon the hull so that it will float on an even keel. In fact it would be a disadvantage to do so, as the extra weight is needed at the forward end to hold the spuds down, and when the dredge is pinned up she is in the best position for work.

The A-frame and boom are of steel, and are clearly shown in Fig. 2, which is a view of the front end of the dredge. The A-frame is 53 ft. high, and the boom is 53 ft. long, and weighs 30 tons. The dipper handle is of wood, reinforced with steel plates, and, as already stated, it carries a dipper of 8¼ cu. yds. capacity and weighing 16 tons. As the dipper is operated by wire rope, single whip, it is expected that the dredge will work very rapidly. She is guaranteed, in fact, to make a full revolution with a load from water 25 ft. deep every 40 seconds, which is a capacity of from 5,000 to 6,000 cu. yds. per ten-hour day.

Perhaps the most distinguishing feature of the dredge is the use of the single part wire rope hoist instead of the chain hoist for the dipper. The reason for this innovation, as stated to us by the builders, was as follows: As dipper dredges increase in size a hoisting chain that will withstand the necessary strain becomes exceedingly heavy, and it is also necessary to run it at great speed in order to make time. This necessitates a great waste of power and wear and tear of the chain and sheaves. A hoisting chain, to do the work of this great dredge, would be three parts 2½ ins. in diameter, and 275 ft long, and would weigh about ten tons. It would require four sheaves, which should not be less than 6 ft. in diameter, and would probably weigh about two tons each, or a total of eight tons. It will readily be seen that the friction and wear and tear on this chain would be enormous, and the horse-power required to move it would be considerable. Moreover, when such a chain breaks, as it sometimes does without notice, it is a serious task to fish it up again. So much for the disadvantages of the chain hoist for very large dredges.

Attempts have been made to substitute wire rope for chain by using three parts of rope and binding them around the sheaves in the usual way, but this method has not been altogether satisfactory, as the frequent bending and friction of the ropes against each other caused them soon to wear out. In 1890 Mr. John Kennedy, Chief Engineer of the Harbor Commissioners of Montreal, introduced the first wire rope dredge for large and heavy work on the single rope plan. This dredge was designed for digging hard material, such as shale rock, etc., in 40 ft. of water, and had a direct pull of 120,000 lbs. The results obtained with the dredge were highly satisfactory, and three others have since been built which are almost its exact duplicates. It has been found that these dredges all possess exceptional speed of working, as compared with chain dredges, especially in deep water, for the reason that the dipper can drop so much more freely with the direct wire rope than is the case when it is required to overhaul three parts of chain. With the wire rope it falls almost with the speed due to gravity, being restrained but slightly and checked up at the right moment as it nears the bottom, whereas with the chain its descent is comparatively sluggish.

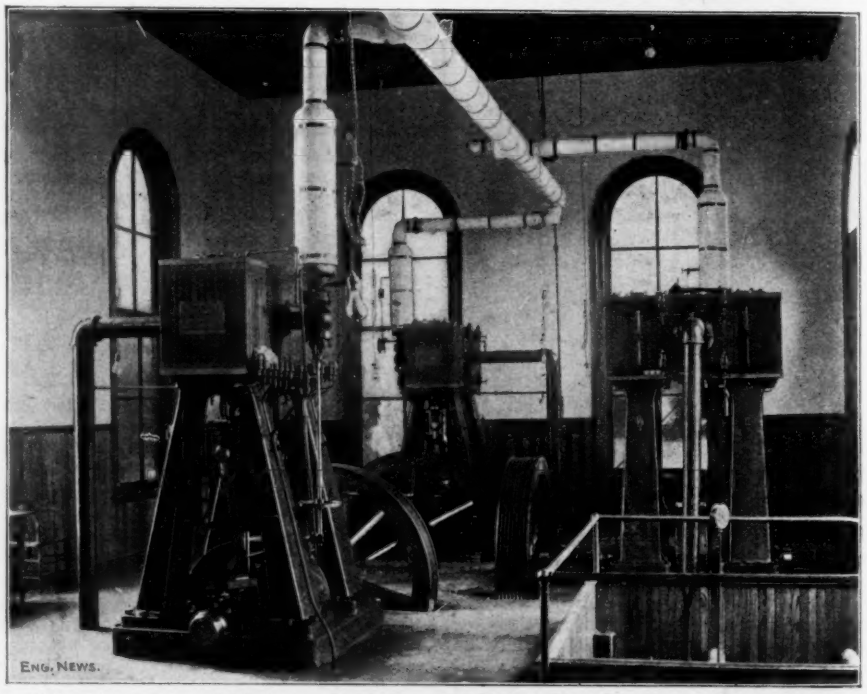


FIG. 4.—INTERIOR OF PUMPING STATION, SHOWING ENGINES WITH ROPE TRANSMISSION TO THE CENTRIFUGAL PUMPS.
Byron Jackson Machine Co., Builders.

Another incidental advantage of the wire rope over the chain is the angle of lead of the pull upon the dipper. It will readily be seen that it is desirable to have this lead as far out as possible in digging, in order that as large a component of the strain as possible may go into a push upon the scoop and not into compression of the dipper handle. In the case of the "Pan American," the lead of the rope is 20° further out on the boom than if the usual three parts chain were used for the same length of boom. This is due to the fact that a single sheave of large diameter is used at the extreme point of the boom, instead of two sheaves, mounted as usual, back of the end of the boom. An additional advantage of the wire rope over a chain is that, after it becomes worn, it gives warning of a break by some of the wires breaking. In this way its failure is a gradual one and gives opportunity to replace the rope, which can be done very quickly. A chain, on the other hand, breaks without warning, and lets the dipper and a large portion of the chain go to the bottom, and in such large machines it requires many hours work and delay to raise and repair.

The hoisting rope of the "Pan American" is extra flexible plow steel, 2½ ins. in diameter, and turns over sheaves 8 ft. in diameter. It is operated by an 18 x 24-in. double high pressure engine, a general view of which is given in Fig. 3. It will be seen that the engines are of very substantial construction, having the drum and gearing all self-contained in one pair of frames. The main hoisting gears are 12 ft. in diameter, 12 ins. face, and 4½ ins. pitch, and power is applied to them by means of a steam thrust operating two band frictions. The friction bands are 12 ins. wide and are lined with wood blocks, and the friction housings are also of cast steel, turned to a perfectly smooth surface. The steam cylinder for applying the friction is so designed that the power can be applied gradually and slipped to any desired degree. This is done by special arrangement of the valve motion, whereby the movement of the plunger

connected to the cylinder follows the movement of the hand on the operating lever and coincides with it.

Besides the main hoisting engine there are a 10 × 14-in. double swinging engine and a 9 × 12-in. double backing engine. A separate engine runs the electric plant, and there are a number of steam thrust cylinders for various operations. In fact the whole of the more important operations of the dredge are controlled by steam so that the labor of the operators is reduced to a minimum. The builders assert, in fact, that despite its great size, this dredge will be handled with less physical effort than most small old style machines. Steam is supplied to the various cylinders by a pair of 8½ × 12-in. return flue marine boilers, operating under 150 lbs. steam pressure. These boilers were built by Farrar & Treffts, of Buffalo, N. Y. The coal bunkers have a capacity of 150 tons. To indicate further the accommodations of the dredge it may be stated that she is provided with state-rooms, office, bathroom, and a dining-room for 40 persons, and is lighted by electricity throughout. The "Pan American" sailed from Buffalo on May 8 for Portage Lake, where her owners have a large contract for dredging. So far no records of her work are available.

RELIEF MAP CONSTRUCTION.*

By Frank G. White.

If a relief map of a certain plat of ground is desired, generally the first thing to be obtained is a good contour map. One method which does not require this will be referred to later. If the area is small and is to be platted to a large scale, rather a careful survey should be made. A convenient method for a small area is to lay it out in one hundred-foot squares and take levels at each corner of each square.

If a large area is to be mapped a quicker method of making the survey must be used. Base lines may be laid out, levels taken at points where there is a decided change of grade, and measurements taken from these points perpendicularly to a base line, the plus to the point of intersection being measured at the same time. Or the rod may be set to give the proper elevations and points on the contours found by trial, measurements to base lines being taken as before.

The proportions between the vertical and horizontal scales usually used are from 1 : 1 or 2 : 3 for gently undulating ground on a large scale, to 1 : 10 or even greater for country on a very small scale. If the country is mountainous the exaggeration required will, of course, be less.

There are several methods of constructing models, all differing materially. Perhaps the one most used is the method of building up on the contours. A tracing is made of each contour and these tracings are pasted on sheets of cardboard, metal or thin boards, the thickness of which will be equal to the contour interval on the scale chosen. These are then sawed out by a scroll or band saw and arranged in order on a suitable base. The model is then in the form of a series of steps or terraces, the surface of each representing the level of the corresponding contour. These steps are then filled with some plastic material and the whole painted and finished off as the modeler desires.

If the map is to be made all of boards, or cardboards, as the case may be, a slightly different course is pursued. When the contours are laid down on the base each is elevated one contour interval from the corresponding contour in the case just cited. Thus a series of steps are produced, the angles of which must be carved off instead of being filled in. A model of this kind has the advantage of being all of one material so that there are no plastic substances to set and shrink away from the wood. On the other hand, it is more difficult of construction, only an experienced carver being able to produce easy, graceful curves.

A method fundamentally different from the ones described is used when the entire model is to be filled with a plastic substance. Parallel lines are drawn across the contour map and upon strips of paper profiles of these lines, taken from the contours, are platted. These profiles are then pasted upon strips of wood or tin and the strips are sawed along the lines. They are then tacked in position on a base as before, similar profiles of the boundaries of the tract, and if necessary cross-profiles, are constructed and tacked in place. The boxes thus formed are then filled, and the top is smoothed and dressed off by resting a straight-edge upon the profiles and drawing it across the model. It will be seen that in this method no contour map is necessary, as the elevations of the line, the profile of which is to be made, may be taken and platted directly.

A method closely resembling this was suggested by Mr. Gaylord Weeks of the present senior class of the University of Iowa and tried in the laboratory. A careful tracing of a contour map was made and tacked on the base intended for the model. Tin strips of different widths were cut, the difference in each case being equal to the contour interval to the reduced scale. Wire finishing nails were then driven into the base on the contour lines, and the strips of tin woven in and out around the nails. The spaces were then filled and the surface smoothed off by allowing the straight-edge to rest on the tin strips while being used as a scraper.

The substances which are used as a filling for relief maps seem to be very few in number. Paper pulp has been used to some extent, the great objection to it being that it absorbs moisture very readily. It is, however, very easy to handle, and if the surface were well shellaced this difficulty would no doubt be obviated. In a paper on this subject by Mr. O. B. Harden, which was published in Vol. X. of the "Trans. of the Am. Soc. Mining Engineers," the author gives the following compound as suitable for work of this kind: Yellow beeswax, 16 parts; corn starch, 8 parts; Venetian red, 1 part; Venice turpentine, 4 parts; sweet oil, 1 part. The wax must be soft and plastic but tough and not sticky. Mr. Harden also states that clay may be used to some advantage.

A mixture which was tried here in the laboratory was composed of 3 parts Portland cement, 1 part flour and just a little corn starch, about 2 or 3 ozs. in 5 lbs. This seemed to work very well, the greatest trouble being on account of the shrinkage when dry. When mixed with the proper amount of water it had about the consistency of putty and was easily smoothed if the trowel was kept continually wet. This mixture did not seem to set, but simply dried out, and could be worked again by moistening the surface. After drying out thoroughly it could be dressed off with sand paper.

For reproducing the models, plaster of paris is used. The map is first coated with soap suds to keep the plaster from sticking, and an impression is made. From this negative any number of models of plaster may be made by simply taking a cast.

*From "Proceedings of the Iowa Engineering Society," January, 1899.

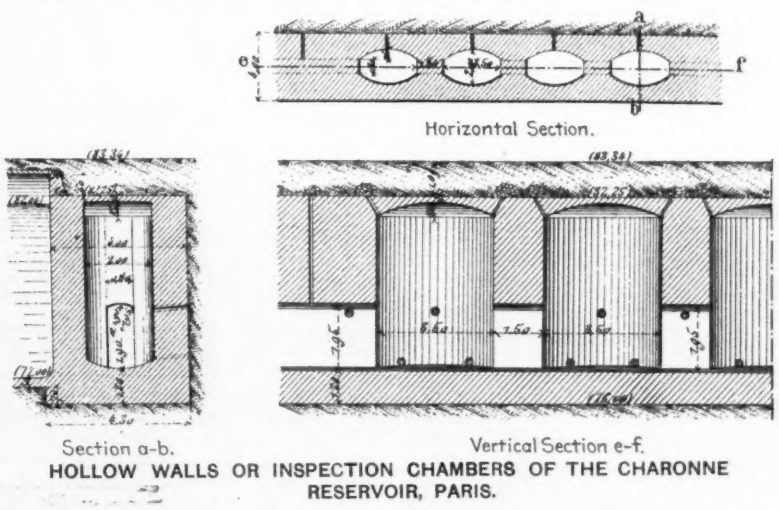
THE HOLLOW WALLS OR INSPECTION CHAMBERS OF THE CHARONNE RESERVOIR, PARIS.

The city of Paris is building a new reservoir at Charonne, to take the place of an old reservoir having a capacity of only 1,320,000 gallons, used for distributing river water pumped from the Seine by works at the bridge of Austerlitz and at Saint-Maur. The new reservoir will contain 7,920,000 gallons. It is built of masonry, with two divisions, and will be completely covered by flat arches and earth.

The chief novelty in construction is in the main walls, which follow the plan adopted by Mr. Humblot in building the reservoirs of Saint-Cloud, in 1892-93. As shown in the sections, these walls are hollowed out by a series of vertical opposing arches of about 10 ft. span, separated by piers about 5 ft. thick on the axis of the wall; and these piers are also arched in their lower part. The openings thus left in the wall are covered by an arch at the top, springing from the separating piers mentioned. This arrangement, continuous in the outer walls, and also used in the wall separating the two reservoir divisions, forms a gallery which is accessible at all times and is used for locating and stopping any leaks which may appear in the masonry of the interior wall. This gallery also facilitates the removal of any water that may filter through the soil adjoining the reservoir or come from the soil which covers the arches over the reservoir. Clay drains, 2½ ins. in diameter, are built into the outer wall, or lead to the upper soil, for this purpose.

Five wells, each 5 ft. in diameter, and fitted with ladders, lead to the gallery from the corners of the reservoir, and from the center wall. The center wall and the north wall are each 4 m., or 13.12 ft., in total thickness, and the three other walls are each about 10 ft. thick in all; they support a depth of water of 5 m., or 16.40 ft. The original article in the "Nouvelles Annales de la Construction" goes elaborately into the mathematical discussion of the stresses in these walls.

A similar feature in reservoir construction was used in this country nearly sixty years ago, at Fifth Ave. and 42nd St., New York City, but only the outer wall was hollow in this case.



HOLLOW WALLS OR INSPECTION CHAMBERS OF THE CHARONNE RESERVOIR, PARIS.

ENGLISH EXPERIENCE WITH GARBAGE AS FUEL FOR ELECTRIC LIGHT STATIONS.

A conservative review of the most notable English attempts to utilize the heat from garbage crematories, or refuse destructors, for producing electric lighting current, was presented by Mr. A. H. Campbell, Assoc. M. Inst. C. E., City Engineer and Surveyor of Canterbury, before a recent meeting of the Municipal and County Engineers.

Mr. Campbell opened his paper by describing a combined refuse destructor and lighting plant now under construction for his city. He stated the "leading principles which governed the design" of the plant as follows:

(1) Exclusion from the engine and dynamo rooms of all dust from the refuse.

(2) The dust destructor must work either alone or in combination with the electric plant.

(3) Sufficient furnace capacity to burn the day's refuse in ten hours, between noon and 10 p. m.

(4) Provision of accumulators for storing current generated in the afternoon.

The destructor consists of two cells. The builders, Beaman & Deas, guaranteed the burning of 15 long tons of refuse in twelve hours, under forced draft, to a hard innocuous clinker; also to evaporate by the destructor gases alone 2,800 lbs. of water per hour from and at 60° F., at an assumed pressure of 125 lbs. per sq. in., being at the rate of 1 lb. of steam produced and 1 lb. of refuse consumed, during ten hours, the balance of time being allowed for getting up steam. No results from this combined plant could be given, as the destructors were not yet in use.

The author next reviewed three combined plants, which have been burning refuse and generating electric current on a large scale for some time. These, with the contractors, are as follows: Oldham, Horsfall Furnace Co.; Shoreditch, Manlove, Alliott & Co.; Llandudno, Beaman & Deas.

Regarding the Oldham destructor, Lord Kelvin and Professer Barr recently reported that it consumed 7.96 long tons of refuse per cell, leaving 32.9% of the original, unscreened mass as ashes

and clinker; the boiler pressure was 128 lbs. and the evaporation per pound of refuse ranged from 0.88 to 1.33 lbs.

No definite figures regarding the Shoreditch plant were given, but an opinion was quoted, without comment, that 1 lb. of refuse there evaporates 1 lb. of water.

The Llandudno plant, on the statements of the borough engineer, Mr. Stephenson, leaves 30.5% of clinker and evaporates 1.4 lbs. of water to each pound of refuse. The total estimated amount of refuse destroyed by this plant in one year was 5,800 long tons, of which 310 tons was fish offal and greengrocer's refuse, the balance being domestic wastes. The amount of refuse burned per sq. ft. of grate surface per hour was 71.7 lbs., and each pair of cells had 50 sq. ft. of grate surface. The total population is estimated at 32,000. The destructor works cost about $25,000.

Besides these three plants the author cited 13 towns "at present pledged to the construction of such joint works," one of which was his own town of Canterbury. He also gave some information regarding refuse destructors in use at several other towns. At Hereford, he was informed by the borough surveyor, Mr. J. Parker, a Meldrum destructor has been in use 18 months, all "steam having been raised from ash pit refuse." Before the installation of the destructor Welsh coal had been used as fuel at a cost of about $1,450 a year. The destructor is placed in front of two 6½ × 22-ft. Lancashire boilers. Reference was made in the paper to the use of heat from burning refuse at Southampton for 15 years past. Mr. W. B. G. Bennett, Borough Engineer of that place, in opening the discussion on the paper, stated that recently they decided to use this heat to pump the sewage, and the greater part of the sewage is now raised by that power. Occasionally they found it necessary to supplement the refuse with coal. One gentleman urged that keeping up the destructor fire for only 10 of the 24 hours was poor economy of heat and must be hard on the furnace.

As a whole, the discussion was quite conservative, both it and the paper indicating a strong belief in the possibilities of utilizing garbage and refuse for producing power, but indicating that altogether too rosy views of the matter had been made public by some people.

THE THEORETICAL TREATMENT OF AIR COOLING WATER TOWERS.

By Wm. A. Mosscrop.*

This is a problem in heat extraction, and we have given the following data:

L = the pounds of condensing water to be cooled per hour.
W(T) = the temperature of the hot water.
W(t) = the temperature of the cooled water.
t = the temperature of the original air supplied to the tower.
h = the relative humidity of the original air.

And in order to build the tower we must determine,

R = the square feet of water surface necessary to expose.
Q = the cubic feet per hour of air necessary to be supplied.
G = the pounds of water that will be evaporated.

The size of the apparatus will also depend upon

w = the velocity of the air current in miles per hour.
T = the temperature of the discharged air.

Upon the wise selection of the last two quantities will depend the commercial efficiency of the apparatus.

The air admitted to the apparatus under atmospheric conditions will generally be a mixture of dry air and vapor of water, and when I use the word air it is to be understood as meaning the mixture under its prevailing condition. The air may contain dry air mixed with vapor, or if the air be saturated it may contain also some water in so finely divided a state as to be held in suspension. In this latter condition, unless it is much colder than the water to be cooled, the air will be of very little use as a cooling agent. In any event the air discharged will contain the original air elevated in temperature to T. It will have also an additional amount of water vapor and an amount of water in suspension that has first been made into vapor and then recondensed in the tower. This recondensation partly accounts for the clouds of suspended water that are seen at the discharge outlets of water cooling towers.

*189 Montague St., Brooklyn Borough, New York city.

To establish the formulas let

A = the total B. T. U. to be extracted from the water.
x = the B. T. U. extracted by evaporation and removed as vapor.

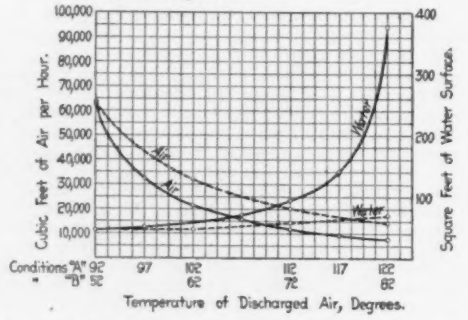


Fig. 1.—Curves Showing the Cubic Feet of Air Per Hour, and the Square Feet of Water Surface Necessary in an Air Cooling Water Apparatus for These Conditions:

Solid lines are for conditions "A."
Broken lines are for conditions "B."

		A.	B.
L	= pounds of water cooled per hour..	1,000	1,000
WT	= temperature of hot water	122	102
Wt	= " cooled water	92	72
t	= " original air	92	42
T	= " discharged air	92-122	52-82
h	= relative humidity, original air	80%	80%
	Relative humidity, discharged air.	100%	100%
w	= velocity, air current, miles per hr.	10	10

A — x = the B. T. U. that will be extracted from the water and transferred to the original air to elevate its temperature from t to T, and consists of three quantities, viz.:

C = the B. T. U. transferred to the original air by recondensation.
B = the B. T. U. transferred to the original air by its contact with the water.
S = the B. T. U. transferred to the air by reducing the vapor temperature from its forming point to the temperature of the discharged air.
G(x) = the pounds of water evaporated to extract x.
G(C) = the pounds of water evaporated to extract C.
E = the rate of evaporation of the water in inches depth per hour.
K = the rate of evaporation of the water in pounds per square feet per hour.
V = the elastic force of vapor at the temperature of the water.
v = the elastic force of vapor in the air.
l = the latent heat of water.
s = the specific heat of the original air at constant pressure.
a = the weight of 1 cu. ft. of original air in pounds.
m = the pounds of vapor a cubic foot of original air will absorb to bring it to its discharge condition.
D = the B. T. U. that will be transferred per hour per square foot per degree difference in temperature between air and its contact surface.

All temperatures are given in degrees Fahrenheit.

In the type of apparatus under consideration, the water is cooled by the action of air under atmospheric conditions. The water is exposed to the action of the air either in films or small drops, and in either case the evaporation and the contact cooling take place at the surface of the water. I shall refrain from consideration of those forms where the water is exposed in drops. In such cases the area of water surface is indeterminate. They have no advantage over apparatus in which the water is exposed as films, in which the area of water surface can be accurately determined. For economical reasons the less mechanical agitation and breakage there is of the water in its passage through the cooler the better.

In view of the well-known conditions under which the cooling action takes place, it seems hardly necessary to go minutely into them. They can be stated briefly as:

(1). Cooling by the evaporation of some of the water through the action of its own heat. (2). Contact of the air with the water surface exposed. 3. Contact of external air with the walls of the tower.

The third cause of cooling is so variable and indeterminate that it will be found advisable to treat it as a factor of safety; take its benefits if there be any, but proportion the apparatus so it will do its work regardless of them.

To solve our problem it is necessary to find an expression by which we can determine the rate of evaporation from the surface of water in contact with air under known conditions of temperature and humidity and velocity of air current. In the "Transactions of the American Society of Civil Engineers," Vol. 15, September, 1886, is a very exhaustive paper on this subject by Mr. Desmond Fitzgerald. His experiments cover the evaporation of water from the surface of still ponds and reservoirs and from them he derives a formula for practical use as follows:

$$E = \frac{(V - v)\left[1 \frac{w}{2}\right]}{60}.$$

Readers are referred to the paper for the details of the experiments.

This formula is applicable to air cooling water apparatus where the water is exposed in films, the thickness of the film having no effect upon the rate of evaporation. The velocity of the flow of the film can be introduced as a correction of the actual velocity of the air current, in which case w would become the velocity of the air current relative to the water surface. The evaporation in pounds per square foot per hour would be

$$K = 5.184\ E.$$

The total heat necessary to extract from the water is determined by the formula:

$$A = L\ (W(T) - W(t)).$$

While x and Q are determined by the formulas:

$$x = Q\ m\ l.$$
$$A - x = Q\ a\ s\ (T - t).$$

so that by elimination we obtain

$$x = \left[\frac{m\ l}{a\ s\ (T - t) + m\ l}\right] A.$$

$$Q = \frac{A}{a\ s\ (T - t) + m\ l}$$

in which x and Q are the unknown quantities. m will depend on T and can be determined for saturation of the discharged air by the formula:

$$m = n(T) - h\ n(t),$$

in which n equals the pounds of water vapor a cubic foot of saturated air will hold at the temperature denoted by the respective suffixes.

T will be selected by the designing engineer and the importance of selecting a proper value for T is shown by the curves of Fig. 1. In fact the

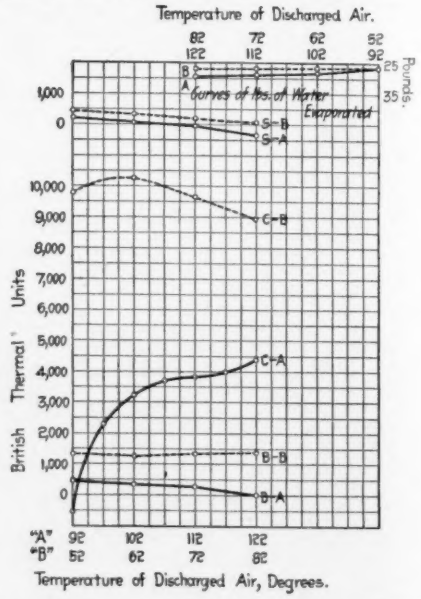


Fig. 2.—Curves Showing the B. T. U. Extracted From 1,000 lbs. of Water Per Hour in an Air Cooling Apparatus for the Conditions A and B, Described on Fig. 1:

C = B.T.U. transferred to the air by recondensation.
B = B.T.U. " " " contact.
S = B.T.U. " " " from the vapor to reduce its temperature to the temperature of condensation.

most important point brought out by these formulas is the influence of T upon the proportions of the apparatus. In such tests as I have seen reported T has been omitted.

To determine R it is necessary to determine C, B and S, of which C and B can be written in terms of it.

$$A - x = C + B + S,$$

and

$$B = D\ R \left\{ \frac{(W(T) - T) + (W(t) - t)}{2} \right\},$$

in which D is a coefficient determinable from experiment and the expression

$$\frac{(W(T) - T) + (W(t) - t)}{2}$$

is the mean difference between the temperature of the air and the water surface.

Experimental values for D are very meager and it would be of great value to have them redetermined. The values used in the computations from

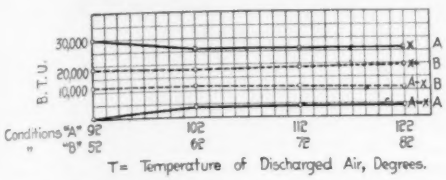


Fig. 3.—Curves Showing the Relation Between the Heat Discharged as Vapor (x) and That Discharged by Elevating Air Temperature (A — x).

which the accompanying curves were plotted were obtained from "A Practical Treatise on Heat," by Thomas Box, pages 206 and 229. The values are given in this table:

For temperature differences of	Constant per square foot.	Multiplier.	D.
18°	.5945	.94	.5588
36°	.5945	1.11	.6590
54°	.5945	1.22	.7253
72°	.5945	1.305	.7758
90°	.5945	1.372	.8157

To determine S we can write:

$$S = .475\ K\ R \left\{ \frac{W(T) + W(t)}{2} - T \right\},$$

in which all the quantities are determined except R. The number .475 being the specific heat of water vapor at constant pressure. The expression for temperature difference represents the difference between the mean temperature of the water

$$\frac{W(T) + W(t)}{2}$$

and the temperature of the discharged air. So that by substitution we obtain S in terms of R. Finally to determine C we can write:

$$C = (A - x) - (B + S).$$

And to determine R we have:

$$R = \frac{x + C}{l\ K},$$

in which by substitution of the value of C we obtain:

$$R = \frac{A - (B + S)}{l\ K},$$

in which we can substitute B and S in terms of R and obtain an equation in which R is the only unknown quantity.

To illustrate the possibilities of the formulas I have computed results for two sets of conditions as follows:

		Conditions A.	Conditions B.
Pounds of water to be cooled per hour	L	1,000	1,000
Temperature of hot water	W(T)	122	102
" cooled water	W(t)	92	72
" original air	t	92	42
" discharged air	T	92-122	52-82
Relative humidity of original air	h	.80	.80
Velocity of air current, miles per hr.	w	10	10
Air discharged at saturation.			

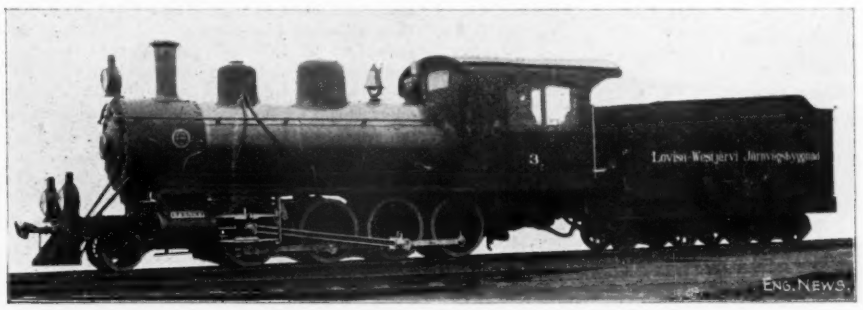
Fig. 1 shows the relation between the cubic feet of air necessary to be furnished per hour and the square feet of water surface that must be exposed, and a look at the curves will show the marked influence of the temperature of the discharged air, especially upon the amount of air required.

Fig. 2 shows the relation between the quantities C, B and S, and also the relation between the amounts of water that will be evaporated in each case.

Fig. 3 shows the relation between x, the B. T. U. discharged as vapor, and A — x, the B. T. U. discharged by elevating the temperature of the original air.

AMERICAN LOCOMOTIVES FOR FINLAND.

Two mogul passenger engines and three consolidation freight engines have recently been built by the Brooks Locomotive Works, of Dunkirk, N. Y., for the Lovisa-Wesijarvi Railway, of Finland. This is a narrow gage line, with a gage of 2 ft.



CONSOLIDATION ENGINE FOR THE LOVISA-WESIJARVI RY. (FINLAND).
Brooks Locomotive Works, Dunkirk, N. Y., Builders.

5½ ins., and is independent of the State railways, which have the Russian standard gage of 5 ft. The accompanying illustration represents one of the freight engines. The passenger engines are of similar design, but with the main driving axle midway between the leading and trailing drivers, while a balloon smokestack is used. All the engines have piston valves, but the moguls have flat rods, while the consolidations have connecting rods of I-section. Large cabs, built of steel plate, are used, and the heavy looking eight-wheel tenders have steel frames, large tanks and small wheels. The engines are to burn either coal or wood as fuel.

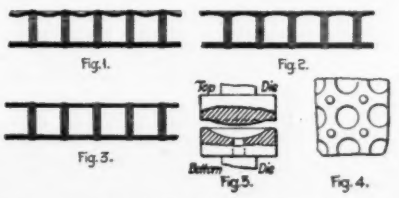
The leading dimensions of these engines are as follows:

	Type of engines—Mogul.	Consolidation.
Driving wheels	3 ft. 1 in.	3 ft. 1 in.
Wheelbase, driving	10 " 0 "	11 " 0 "
" engine	16 " 0 "	17 " 0 "
" engine & tender	37 " 6⅝ ins.	39 " 1⅝ ins.
Weight on drivers	43,000 lbs.	52,919 lbs.
" on truck	7,717 "	7,716 "
" total engine	50,717 "	60,635 "
" tender, loaded	46,297 "	46,297 "
Cylinders	12½ × 18 ins.	14 × 18 ins.
Boiler, diameter	3 ft. 10 ins.	4 ft.
Boiler pressure	150 lbs.	150 lbs.
Firebox	92 × 20 ins.	11 × 20 ins.
Tubes, number	120	147
" diameter	2 ins.	2 ins.
" length	8 ft. 2 ins.	8 ft. 2 ins.

CORRUGATED FIRE-BOX SHEETS FOR LOCOMOTIVE BOILERS.*

By R. J. O'Neil, Boiler-Shop Foreman, Chicago & Alton Ry.

There is no doubt that all boiler foremen and master mechanics have noticed the difficulty of late in keeping stay bolts tight in side sheets and of keeping side sheets from cracking in locomotive boilers. Of late years the tendencies are to increase the steam pressure on locomotive boilers, and by doing so we are strengthening the boilers by using heavy material, but from long experience we find that the best results are obtained by making the sheets next to the fire as light as possible, say such as 5-16 or ⅜-in. thick, while the outside or cylinder parts of the boiler is made from ½ to 1 in. thick; hence we notice that the sheets next to the fire, although being light, have to stand this heavy pressure as well as the severe heat. We are therefore forced to apply stay bolts in those sheets in order to help strengthen them, and thus we cause our trouble by leaking and cracking of the sheets outward from the bolts. By close observation and long experience I have found that a stay bolt is capable of supporting a certain area only from the bolt, and the fewer stay bolts applied the less leaks we have from stay bolts. So the idea has occurred to my mind to strengthen the sheet between the stay bolts by means of depression or corrugation, as shown in Fig. 1. We find that in the present practice of staying boilers the sheet between the stay bolts is the first to give or bulge out toward the fire, as shown in Fig. 2, and by so doing causes this extra strain on the stay bolt, pulling the sheet from the inside of the stay bolt, leaving the stay bolt hole tapering, causing the bolt to leak and break as well as cracking the sheet. Some may call this expansion, but I have found that the best way to overcome expansion is to make the necessary allowance for it, as it is useless to try to prevent it. Therefore, by the depressed or corrugated plates we overcome this expansion by giving it this natural curved elastic depression, as shown in Fig. 1, the expansion going to the inner side instead of to the outside, and helping to take the strain off the stay bolt, keeping it from leaking and breaking, as well as preventing the sheets from cracking. As the tensile strength of steel depends almost entirely on its hardness, and as carbon is one of the elements that tends to make steel brittle and hard, we have proven by a test that we can reduce the tensile strength from 30 or 35 tons per sq. in. to 22 or 25 tons per sq. in., as we gain extra strength by our elastic form of depression. There is no doubt that punching injures all steel plates more or less, and the harder the material the greater the injury to it. Hence plates 30 to 35 tons per sq. in. suffer more than plates 22 to 25 tons per sq. in. It may be said of the depressing that it might injure the steel, but such is not the case, as it benefits it instead, because it is a circular form and only depresses the thickness of the steel itself and affords no means for sediment to adhere to the plates any more than to the original straight plates. Therefore, I would recommend all steel plates to be depressed, then annealed in a pine wood fire, if possible, and then drilled, in order to get the best results therefrom.



Sketches Illustrating Method of Cupping Fire Box Sheets for Locomotive Boilers; Chicago & Alton Ry.

Fig. 3 represents the inside and outside walls of a firebox in its natural form. Fig. 2 represents the walls of a firebox, the way we find the sheets bulged out toward the fire, between the stay bolts, pulling the sheets from the inside of stay bolts, caused by the pressure and severe heat after being in use for some time. Fig. 1 represents our form of depression between the stay bolts. Fig. 4 represents the circular view of the depression between stay bolts, while Fig. 5 shows the top and bottom dies for depressing, which can be placed in any ordinary power punch.

*Reprinted from the "Boiler Maker" for June.

AN ENGLISH BACTERIAL SYSTEM OF SEWAGE treatment has been patented in this country by Mr. Wm. Dundas Scott-Moncrieff, of London, England. The sewage is first received in a tank partially filled with broken stone, where aerobic bacteria break down the organic matter until the available oxygen of the sewage is exhausted. Next the anaerobic bacteria play their part. Subsequently the sewage is decanted intermittently from gravity tipping tanks to the first of a series of superimposed trays, filled with filtering material. The sewage drips from one to another of these trays until it has passed them all. In this part of the process, aerobic bacteria are supposed to complete the purification of the sewage. The system has been before the public in England for some time and seems to be regarded favorably there, but we have seen no definite statements as to its cost. The American patent is No. 624,985. Another patent taken out at Washington by an Englishman (No. 625,605, granted to G. E. Ridgway, of Ashley) covers an apparatus for automatically distributing sewage to a number of beds or tanks in rotation. This is effected by the rise and fall of the liquid, operating a series of levers, floats and siphons.

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ADVERTISING RATES: 20 cents a line. Want notices, special rates, see page XXII. Changes in standing advertisements must be received by Monday morning; new advertisements, Tuesday morning; transient advertisements by Wednesday morning.

The Irish Channel tunnel scheme, which has been agitated at intervals for many years, has been again brought into public notice by the visit of a deputation to Parliament to ask that the Government should "take the project into consideration." The deputation was received with the usual politeness, a hearing was given to its arguments, and there the matter is fairly certain to end. The proposed tunnel would be somewhere from 25 to 30 miles in length, and would have to be driven under water which is supposed to be some 80 fathoms in depth. We need hardly say to our readers that tunneling under water at such a depth is something for which no precedent exists. The great achievements in submarine tunneling of the past two decades have practically all been accomplished with the aid of compressed air to keep out the water which is certain to enter otherwise. The necessary air pressure varies directly with the depth below the water level, and a pressure of about 75 lbs. per sq. in., corresponding to a depth of about 175 ft., is the greatest that has ever been attempted, and that only on an experimental scale. The difficulties and expense of tunnel or foundation-work under an air pressure greater than 35 to 40 lbs., are so great that even these pressures are only used in case of absolute necessity, and then for the shortest time possible.

Under these circumstances, the only possibility, in the present state of the art, of making a submarine tunnel at any such depth as that proposed for the Irish Channel tunnel would be through the existence of an absolutely impervious rock stratum, extending entirely across the channel, through which the tunnel might be pierced. The existence of any such stratum is in the highest degree improbable, and even if it existed, it would be impossible to demonstrate it in advance of driving the tunnel. Taking these facts into consideration, our readers can estimate for themselves the chances that either gullible investors or the British Government itself, can be induced to invest the fifty to seventy-five million dollars which are now mentioned as guesses at the cost of the work. We may add that thus far no one has shown anything more than a sentimental demand for the tunnel. Such passenger traffic as exists is not likely to prefer a 25-mile ride through an under-sea tunnel to the trip across by a comfortable steamer, and freight traffic can be carried more cheaply by sea, anyway.

It is curious to observe the efforts which are put forth in these days by well-meaning, but uninformed, persons in advocacy of two classes of quixotic enterprises. One class, that to which this channel tunnel scheme belongs, consists in substituting railway for water transportation over natural bodies of water, such as the English and Irish channels, or the Straits of Gibraltar. The other class includes the more numerous set of schemes which propose the substitution of water transportation for rail transportation over land. One would think that, in the absence of engineering knowledge, ordinary horse-sense would teach that the railway car is the more economical vehicle for land transportation, and the ship for transportation by water; but even so crude a generalization as this seems beyond the reach of certain of these advocates. We do not overlook the fact that most of the projects for tunnels or bridges to carry railways across waterways, and most of the canal projects as well, have it as their object to avoid a break in a continuous passage by rail or by water, as the case may be, with the accompanying necessity of trans-shipment. In all such cases a careful comparison of costs with benefits will determine whether the project is a sound one. Such a comparison appears to be deemed superfluous by both the bridge and tunnel men, and the canal advocates to whom we have referred above; but without such a comparison no scheme is likely to receive much support in the financial world.

The filtration of public water supplies has awakened a number of cities and towns to the necessity of curtailing the waste of water. To this cause of awakening there is now being added another, and somewhat allied one, the necessity of purifying sewage. Just as a number of municipalities are realizing the folly of purifying a gallon or two of water to be wasted for every one that is used, other cities are seeing that the problem of sewage purification is unnecessarily great through the waste of water. Of course this relates principally to places having the separate system of sewerage, not so much because water waste does not matter in such cases, as because the sewage from only a few combined systems is being treated in this country, though it is commonly done abroad. These reflections have been suggested by the situation at Saratoga Springs, N. Y. That place is obliged to adopt a system of sewage treatment within a year, and the sewer commissioners are confronted by the enormous consumption and waste of water. They have conferred with the water commissioners and the latter are reported as having decided to introduce meters and to take other measures to cut down waste. Many other cities and towns, which, through carelessness, ignorance, or fear of political consequences, are wasting more water than they are using, will soon be brought up short by the expense involved in such mismanagement or the difficulties of securing a sufficient supply of pure water, and of its final disposal after becoming fouled. Prudence will be shown by throttling waste before it reaches huge proportions, and comes to be considered as a matter of right and merit instead of a financial and sanitary wrong.

An excellent opportunity to pursue geological investigations is afforded by the test pits, wells, and other excavations carried on in connection with engineering works, and a large proportion of the world's present knowledge of the earth's structure is due to the aid thus afforded. Nevertheless, many a fine chance for geological research has been lost because no geologist was at hand when the work was in progress, and no care was taken by those in charge to make and preserve records of the strata pierced. Our State and National geological surveys would do well to keep thoroughly posted as to the progress of engineering works, and have men on the ground to take full advantage of the opportunities thus afforded.

We are pleased to note that this very thing has been done in the vicinity of Clinton, Mass., on the site of the Wachusett dam and aqueduct of the new Metropolitan Water Supply System. A portion of the results thus obtained is given in the "Technology Quarterly" (Boston), for June, 1899, in an article by Prof. W. O. Crosby. The article does not make clear whether the work of geological exploration was done privately, or for the U. S. Geological Survey. The latter, however, will doubtless profit by the work, as the author of the article states that Prof. B. K. Emerson is studying the Nashua valley for the Survey. The tunnel in question, the many test borings to aid in locating the dam, and the surface and sub-surface exposures due to de-foresting, and stripping the site, together with a variety of trenching and other work, Prof. Crosby states, have afforded him unexcelled facilities for his researches. The author acknowledges assistance given by Mr. F. P. Stearns, M. Am. Soc. C. E., Chief Engineer of the Board, and by Messrs. T. F. Richardson and H. A. Miller, M.'s Am. Soc. C. E., Department Engineers at Clinton. This suggests that engineers might often bring such opportunities to the attention of local geologists or those in charge of geological surveys. Such a course would be of mutual advantage, for engineers are quite as much interested in geological formations of specific localities as the geologists themselves, and should do what they can to extend available information on the subject.

THE REAL ADVANTAGES OF ELECTRIC MOTIVE POWER.

That threadbare old question, the electric motor vs. the steam locomotive, was one of the set topics for discussion at the recent Cape May convention of the American Society of Civil Engineers; and the handling it received gave good grounds for congratulation that the verbal discussions before this Society receive some radical editing before they are presented as engineering literature in the Society's transactions. Unfortunately the newspaper reporter in search of sensations, was present and escaped the Secretary's editorial supervision; and, as a result, the newspapers from Maine to California have reported the discussion as advocating rubber-tired wheels for locomotives, and various similar eccentricities, in connection with the use of electric motors.

Passing, however, those features of the discussion, which contributed to the amusement of those present rather than to the advancement of knowledge, the discussion as a whole appeared to us to be generally defective in that attention was directed almost entirely toward one aspect of the situation; that is, the relative cost of power by the steam and by the electric systems. It appears to us, moreover, that this is an exceedingly common defect in engineering investigations of subjects of this sort, and it is one which engineers ought to correct, if they would take the place which they ought to take as professional advisers. The business man too often distrusts the engineer, and not without reason, because the engineer—not always, but too often—looks at questions from too narrow a point of view. In this matter of electric railways, for example, it is not the cost of power—the relative drain on the coal pile—that tells the advantage or disadvantage of the electric motor. That is "a minor consideration" in almost all cases. What tells the story is other economies in operation or gains or losses in traffic. For example, there are hundreds of local passenger trains running in different parts of the country consisting of a locomotive, a baggage car and a passenger car, the whole run by a train crew consisting of engineer, fireman, conductor and brakeman, with occasionally a baggage-man besides. Ninety-nine per cent. of the trips of these trains are made with a load no greater than an ordinary electric car would accommodate, yet such a car can be manned by two men whose pay would be not one-third as much as the pay of the crew on the steam train. What the manager wants to know is, what he must invest to make such a saving. Compared with it, the difference in cost of fuel to develop power for the two systems is a trifling matter.

FIG. 1.—GENERAL VIEW OF DREDGE.

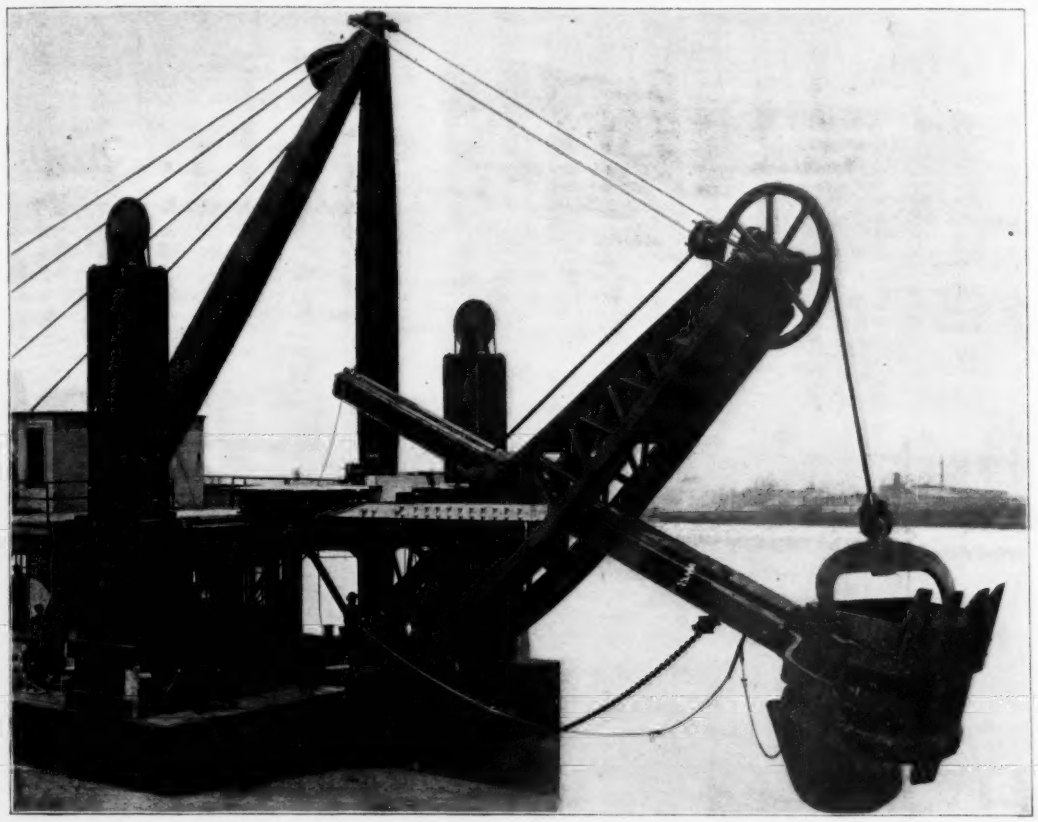


FIG. 2.—VIEW OF FRONT END OF DREDGE, SHOWING A-FRAME, BOOM AND DIPPER CONSTRUCTION.

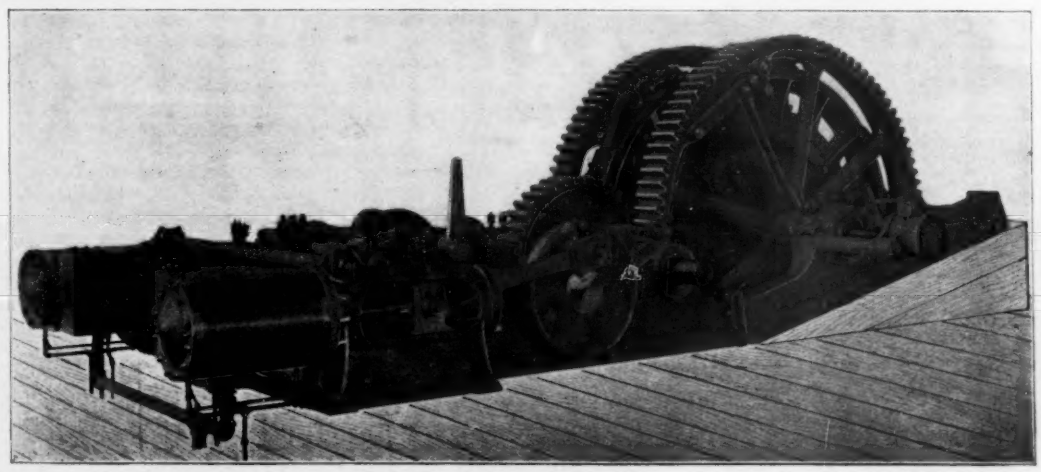


FIG. 3.—VIEW OF 18 x 24-IN. DOUBLE HOISTING ENGINE.

DIPPER DREDGE "PAN AMERICAN."

Hingston & Woods, Buffalo, N. Y., Bucyrus Co., South Milwaukee, Wis., Designers and Builders.

Again, take the substitution of the electric motor for the horse on street railways. The gain which has been made is not measured by the difference in cost of animal traction and electric traction. The great gain is in the increased power of the electric motor, which enabled the companies to run larger cars and run them faster. These two improvements together operate to greatly increase the number of passengers which a car-crew can carry in a day's work, and, at the same time, the faster and more comfortable cars have enormously increased the traffic. A third great gain is the power of operating over considerable grades with very little reduction in speeds, which has revolutionized the street transit problem in many cities.

Still again, take the operation of interurban and suburban railways by electricity, which has so seriously cut down the profits of many steam railway companies. There seems to be a common idea that the transfer of traffic to these new lines is due solely to their use of electricity; and steam railway managers have even talked of getting back their passengers by substituting electric traction for locomotives in their suburban passenger service. It must be clear to any careful observer that this is all a mistake. People forsake the steam train for the electric interurban in going from St. Paul to Minneapolis, for example, because they can take the electric car at their own door or within a few blocks, and be carried to their destination, whereas a journey on the steam train means consulting the time table, going to the railway station, waiting until the train pulls out, and going from the station to the final destination at the other end. If an electric motor were substituted for the steam locomotive it would make no difference. So long as steam railway lines cannot abolish the time table and run their cars through the business streets of cities to deliver their passengers, they must submit with the best grace they can to the loss of a certain portion of the business which they formerly enjoyed.

The specific question which was set for the discussion before the American Society of Civil Engineers was under what circumstances the operation, by electricity, of branch lines from a main line of steam railway might be profitable. Perhaps the wisest thing that was said in the discussion was that every such case should be decided on its own merits; no general rule could be laid down that would fit all cases. There are, for example, places where right of way for an electric line could be secured along a highway, whereas a steam railway would have to secure its own right of way. In some cases electric current can be purchased, and the heavy cost of a power-house and its operation may thus be avoided. Some branches might develop a considerably larger passenger traffic through the use of electric motors than can be expected for a steam-operated line. We give these simply as examples of the diverse items which must be taken into account in order to give a fair decision upon the question at issue. There are, of course, certain branches whose traffic is so heavy that nothing but operation by steam locomotives would be thought of. There are others, however, where only a thorough comparison of the relative merits of the two systems will determine which is the more profitable. Off-hand determinations of such a question are not to be relied on.

We may find still another example of the tendency of engineers to look too narrowly at questions of this class in the current discussion respecting the comparative merits of driving machinery in manufacturing establishments by belting and shafting or by electric motors directly attached. Here, again, one would sometimes think from the discussions that the loss of power in the friction of belts and shafts was the chief reason for substituting the electric distribution of power. As a matter of fact, however, this is a minor consideration. In nearly all manufacturing establishments the cost of power is a small item in the total expenditure. The advantages which make the electric motor worth its added first cost are the better control over the machinery which it makes possible, the higher speed, and increased output which it enables, the improved light which results when the forest of belts and shafting are cleared away. If in addition the drain upon the coal pile is reduced, so much the better, but this is the least important side of the story in most cases.

Another very recent example of this same tendency among engineers is a long and elaborate paper which was read at the recent Boston meeting of the Institute of Electrical Engineers, in which the authors attempted a comparison of the economy of operating parcel delivery wagons by horses and by electric motors. The authors investigated with painstaking care, the actual operation of an extensive parcel delivery system operated with horses in New Yorw city, and found that the total cost of a horse and wagon with one driver and helper amounted to $3.64 per day. They then proceed to a comparison of the costs of the two systems, which we need not here review, but which was made, not on the basis of the use of electric vehicles in actual delivery service, but from tests of the speed and power consumption of electric vehicles run in exhibition tests. They then remarked that the factor most important in determining the expense of operating an electric vehicle is the price that must be paid for the power, and proceeded to discuss various schemes for obtaining current for charging the batteries of the vehicle at a low price.

It appears to us that in this case again the emphasis in the comparison is laid in the wrong place. Very likely motor vehicles may supersede the horse in parcel delivery service; but other considerations than the matter of the cost of horse-power or electric power are likely to be the determining factors. It may be found, for example, that two men can cover a longer route and make a greater number of deliveries in a given time with a motor wagon than with a horse due to the more rapid movement of the former. The motor-wagon may be able to carry a heavier load and go over longer distances, enabling delivery service to be given to more remote suburbs, where express companies are now relied on. The motor-wagon may be found more reliable than the horse on account of the failure of the latter in times of excessive heat; or, on the other hand, the motor may be so balked in its work by snow storms that managers will hesitate to adopt a system which is likely to fail during the holiday season, when trade is most brisk and patrons are most insistent on prompt delivery.

We might further multiply examples, to show that the bare cost of power is only one, and commonly a small one of the items to be considered in comparing the relative value of two competing systems. We might show, for example, that the electric motor is tending to displace the gasoline engine in motor vehicle service on account of the objectionable odor and noise of the latter, even though the electric vehicle shows considerably greater cost for the power consumed. We might instance the substitution of the electric motor for the cable in street railways, where considerations of safety, avoidance of break-downs and adaptability to the traffic were as important factors as the saving of power. Nothing further seems necessary, however, to emphasize our caution that engineers should seek to study commercial questions from the broadest standpoint, and not merely from the single aspect that may appeal to them most directly.

LETTERS TO THE EDITOR.

The Philadelphia Excursions Following the American Society of Civil Engineers' Convention.

Sir: Referring to the side trip to the Pencoyd Iron Works on Saturday, July 1, it has occurred to the writer that it may be lost sight of in comparison with the more generally patronized trip to Cramp's, and in return for the very liberal treatment received the writer asks that you accord to Mr. Percival Roberts due recognition as a model host. One of the striking things seen was the fact that Mr. Roberts was himself intimately acquainted with every piece of machinery in the works.

Very truly yours, J. G. S.

Water Pollution Studies in England and the United States.—Correction.

Sir: Will you allow me to correct the statement on page 13 of Engineering News for July 6, that in my discussion of stream contamination I "said that the report of the River Pollution Commissioners of Great Britain is at present the best authority available as to the extent to which sewage discharge into living waters is permissible."

On the contrary, while referring to the greater mass of information on the subject to be found in England, the Rivers Pollution Commission standards were pointed out in particular as being quite faulty and not in accord with recent experience, while much of the best work in this line to-day is being done in America.

Very truly yours, Kenneth Allen.

Office of Sewerage Commission, Baltimore, Md., July 7, 1899.

A New Test for Slag Cement—Adulteration of Portland Cement.

Sir: I was recently drawn into a controversy by our chemist, who was trying to persuade me that a well-known standard brand of German cement, which we were using for sidewalks, was a slag cement. He found his support in the fact that with a magnet a large amount of fine splinters of iron could be drawn from the cement. This seems a fair test for slag adulteration; and I pointed out the fact that the adulteration did not make the cement a slag cement. Whereupon, with a magnet, I went over some samples of American Portland cement, which had been received from different parts of the country; and, to my surprise, found that the magnet would extract these fine splinters of iron from nearly all of them. One might expect to find evidence of slag adulteration in a German cement, because the manufacture of slag cement in that country is well developed.

The manufacture and use of slag cement in the United States is, however, limited, although the industry is developing rapidly. It, of course, is a less expensive cement than a Portland cement; and it would not be a difficult matter for a dealer to mix the two together.

I have never heard the question of slag adulteration of cement in this country touched on; and if this magnet test indicates slag adulteration—and I cannot see from what other source the iron could come—it is evident that the matter will bear inquiry.

I should like to hear the views of others.

Respectfully, Z.

July 4, 1899.

(Is it not possible that the source of the iron splinters found by our correspondent may have been the abrasion of the metal surfaces between which the clinker is broken and ground in many modern cement mills? It seems to us that this may be at least a possible explanation of the phenomenon. We should be glad to hear from any of our readers who may have further information on this subject.—Ed.)

An Instance of Rail Damage by Slipping Driving Wheels

Sir: The damage resulting to rails and tires from the slipping of locomotive driving wheels when starting heavy trains is familiar to engineers, but the matter was recently brought more forcibly to the writer's attention than ever before by an incident which he witnessed on one of the suburban roads leading out of New York city. At the time, the writer was standing directly alongside a locomotive which was starting a train of five or six passenger cars out of a station on a fairly heavy upgrade on a curve. As the steam was thrown on, the drivers spun around perhaps a half a dozen times without moving the train forward, and then secured their grip and the train pulled ahead. An examination of the rail after the train had passed showed, where the driver had slipped, a hollow perhaps 1-16-in. deep at the center and thinning out toward the edges of an elliptical surface approximately 4 ins. long and half as wide. The metal formerly occupying this hollow had been melted and had flowed or been forced back in the direction of the rotation of the driver in three distinct waves. The distance from the edge of one wave to that of the next was perhaps 1 in. The edges of these waves for the width of ¼-in. or so also showed a brilliant steel blue color, and they overlapped the metal below sufficiently for the writer to insert the edge of his finger nail under them. When first examined, which was of course after the cars had passed over it, the damaged metal was too hot for one to bear his finger on it, and, in fact, it charred the edge of a thin, dry chip which was held hard against it. Briefly stated, the examination showed clearly that the steel of the rail had been melted by the friction of the slipping driver and had been forced out of its original position when in a plastic condition into a clearly distinguished hump, leaving, of course, a corresponding hollow ahead. The incident is perhaps not an unusual one, but it furnished to the writer at least a capital illustration of the damage to track and locomotive driving wheel tires which may result from carelessness of the locomotive driver or other causes bringing about the frequent slipping or racing of the driving wheels.

Very truly yours, H. S. C.

New York city, July 10, 1899.

Tests of a 14-in. Riveted Steel Main at New Westminster, B. C.

Sir: I am always greatly interested in tests by actual observation of the amount of water flowing through pipes under given conditions. I therefore have read with considerable care Mr. Hawks' description in your issue of July 6 of some measurements made by him upon a 14-in. riveted steel pipe at New Westminster, B. C. His measurements seem to have been very accurately made, and the pipe was of sufficient length—over 13 miles long—to average up all probable local variations.

These observations were made in 1896, and again in 1899. In 1896, with a fall per 1,000 of 0.455, the measured discharge was 0.99 cu. ft. per sec. Using Kutter's formula with a value of n = 0.013, Mr. Hawks found the calculated discharge to be 1.07 cu. ft. per sec., or 8% too great.

In 1899, with a fall of 0.584 per 1,000, the average measured discharge was about 1.206 cu. ft. per sec. By Kutter's formula as above, the calculated discharge was found to be 1.227 cu. ft. per sec., or less than 2% too great.

It seems a rather unexpected result to find the pipe's capacity, as compared with the formula, apparently increasing with age.

Let us now calculate the discharge of the above pipe under the two different rates of fall, by the formula,

$$\frac{Q^2}{D^5 h} = 1,$$

which is merely the generalization of Darcy's well-known formula for rough cast-iron pipes of diameters from 1 to 4 ft., and in which Q = cu. ft. per sec.; D = diameter in feet, and h = fall per 1,000. Using this formula we find for the discharge in 1896, Q = 0.908, practically exactly as found by measurement; and in 1899, Q = 1.13, or not quite 6% less than the measured discharge. Here again the pipe runs away from the formula, with age.

It seems probable that the later experiments in 1899, under a greater head, are the most reliable. If we accept these for the purpose of testing the two formulæ, we find that Kutter gives 8% too much, and Darcy 6% too little. Conservative practice will give the preference to the latter.

It must be remembered, also, that the pipe line even in 1899 is only seven years in use, and the coating is still probably intact. In ten years more of service it would be reasonable to anticipate a reduced flow.

E. Sherman Gould.

Yonkers, N. Y., July 7, 1899.

Strength of Wooden Floor Beams.

Sir: Your correspondent, H. T. H., who wishes to hear from other members of the profession on the strength of wooden beams, makes several mistakes in comparing the tables which he quotes in your issue of July 6, 1899, to which may be laid his evident difficulty in harmonizing them.

At the head of the table in Kent's "Mechanical Engineers' Pocket-Book," to which he makes reference, it is expressly stated that the load given is in pounds per foot of span. The table of safe loads for white pine beams in Trautwine's Engineers' Pocket-Book makes allowance for longitudinal shear, by which short beams fail, as in the case of the examples given, before the maximum load is applied to produce the bending moment given by the formula $M = \frac{S I}{C}$. Finally, in assuming S at 1,200 lbs. per sq. in., he uses a factor of safety of 10.8, instead of 6, which is assumed in the above tables which he questions, considering the ultimate breaking stress at 13,000 lbs., which is the present average practice for yellow pine.

South Bethlehem, Pa., July 8, 1899. J. I. R.

Sir: Referring to the letter on floor beams in your last issue, I would state that the table to which reference was made was taken from a work of mine on mill floor construction, and the weight referred to was the distributed load per foot of span and not the total distributed load, as stated in the communication. The formula for concentrated center load being: $W = \frac{R b h^2}{18 s Z}$ = for spruce $\frac{10{,}080 \times 1 \times 6 \times 6}{18 \times 6 \times 6}$ = 560 lbs., and for distributed load double this amount, or 1,120 lbs., and Trautwine, in his formula uses the transverse breaking strength of a beam 1 in. square and 1 ft. between supports, loaded in the middle, which is 1-18 of the modulus of rupture ordinarily given. His constant for spruce is about 20% less than the one I used. The constants of the formulæ which I have used were on the basis of experience in a high class of work indoors, and every engineer is obliged, as a part of the exercise of his professional work, to vary his constants according to the service required of them. I generally use limits of deflection with the modulus of elasticity for transverse loads, as the limit in construction is generally the permissible amount of flexure which is advisable for the structure or its contents and in this way be far within the safe load to be imposed on the beam as far as its breaking is concerned.

It is more accurate to decide upon the average radius of curvature of the curve of flexure of a loaded beam. When the deflection is assumed to be a direct ratio of the span, the deflection would be too great on short spans. This limitation of the radius of curvature can be readily substituted for d in the formula for deflection of a uniformly loaded beam.

$$W = \frac{E b h^2 d}{270 l^3}$$

E = modulus of elasticity in pounds.
b = breadth in inches.
h = height in inches.
d = deflection in inches.
l = span in feet.
w = load in pounds per foot of span.

If the mean radius of the flexure of the beam is 1,248 feet, d = .0012 l^2 and we would have $W = \frac{E b h^2}{225{,}000\, l}$.

Yours very truly,

C. J. H. Woodbury.

Boston, Mass., July 7, 1899.

The Use of Wheel Concentrations in Computing Bridge Stresses.

Sir: In your issue of July 6 you notice the discussion before the American Society of Civil Engineers on the question, "Should the use of the method of wheel concentrations be discontinued in determining the stresses in railway bridges?" and you give the information that the sentiment of those who discussed this question was practically unanimous in answering it in the affirmative, and that "the members vied with each other in poking fun at the old plan of specifying wheel loads." Had the writer, who was prevented by pressure of other matters from attending the meeting, anticipated such a one-sided discussion, he would have taken part in protest against the prevailing sentiment, which he believes does not represent the sentiment of those who have most to do with the calculation of stresses in railway bridges; to wit, the bridge engineers of the railway companies and the engineers of the bridge companies. The question of superiority of method in determining stresses depends on which method, for the same value of bridge, results in the production of the bridge at the least cost. The method used affects the cost in two ways; first, by its effect, according to its accuracy, on the economy of material; second, by the cost, according to its intricacy, of applying the method. The loads on railway bridges are wheel loads. These loads are somewhat distributed by the stiffness of the track which slightly lessens the stresses in the connections of stringers to floor beams and very considerably reduces the pressures on ties and on local points in the flanges of the stringers, but except in these regards the stresses produced are the same as if the loads were concentrated.

As regards material, the most economical method is to take the wheel concentrations of the critical loadings exactly as they are. For present conditions the critical loadings are approximately knowable, therefore for present conditions the method of wheel concentrations is the most accurate. If in a bridge designed for present conditions the loads increase but still maintain the same relations between the various wheel concentrations of both the engines and the cars, then the live stresses will all be increased in the same proportion, and if the bridge was originally well designed by the method of wheel loads, the distribution of the material will remain the most economical. If the past be taken as the criterion whereby to judge of the future, the wheel concentrations will increase but the relations between them will not vary greatly. Even if the relations between the wheel loads should vary greatly in the future in a manner not intentionally provided for, there is no reason to suppose that any method other than the method of wheel concentrations would be more accurate as regards these future conditions except by mere chance. It appears from what has been stated that as regards accuracy the method of wheel concentrations has the advantage. The question of the wisdom of abandoning its use depends on the value of the advantage as to accuracy compared with the increased cost, if any, by which this advantage is obtained. To those who are not familiar with the short ways which have been devised for determining the stresses from wheel concentrations or who from lack of practice cannot use them with facility, the cost of making the calculations probably seems much greater than it really need be. For stringers, floor beams, hangers, plate girders, and single intersection trusses, resting on two supports, the calculation of the stresses from concentrated wheel loads by proficient specialists is a very simple matter; in fact, it takes less time than it would if some of the other systems which have been proposed were used and the cost is insignificant as compared with the total cost of the bridge. Such cases include the great majority of railway bridge work, and for them there would seem to be little advantage in substituting for the method of wheel concentrations an approximately equivalent one, even if a satisfactory one is obtainable. Be this as it may, it is certain that before the method of wheel concentrations can be abandoned, some other method or methods must be selected to take its place. It would be interesting to have all the engineers "who vied with each other in poking fun at the old system" suggest methods in its place and to observe whether there would still be the same unanimity among them. For the trusses of long spans it is not especially difficult to obtain other methods which give results agreeing closely with those obtained from any system of wheel concentrations of usual type and a fair agreement can be obtained for trusses of spans of moderate length, but for short spans and for floor systems the writer knows of no method which gives close approximations in all cases to the method of wheel concentrations. For multiple intersection trusses, for continuous girders, and for some other special cases there is much more reason for adopting some approximately equivalent method, in place of the method of wheel loads, than there is in the cases previously discussed, because for such cases the use of the method of wheel loads is often quite complicated and in some cases it is extremely so. For such cases, even when wheel loads are specified, approximately equivalent methods are frequently allowed and used.

Yours respectfully,

Henry S. Prichard.

Trenton, N. J., July 8, 1899.

Random Notes Abroad.

III.

Sir: From Marseilles to Monte Carlo the travel during "the season" is very large, while from Cannes and Nice—a half hour's run—it is largely increased. No locality offers more tempting profits for an electric railway; but the hard, rocky mountains come down to the sea shore, and the "P., L. & M." has its line laid on the only accessible right of way.

Nice, the winter resort of European fashionable society, is a beautiful city. From November to June it is thronged. Tropical trees and plants flourish in the open air all the year round. The streets of Nice are all macadamized; the road metal, taken from the mountain sides nearby, on being well wetted and rolled, forms a natural cement covering which is as smooth as granolithic; after a rain of any severity this road covering is liquid cement and is scraped to the gutters, where it lies until dry enough to be shovelled into carts; rain is a rare occurrence in Nice, and so the carriage traffic pulverizes the road covering after a few days and clouds of white dust are the result. There are therefore only short intervals of really enjoyable streets.

With such a large and wealthy population as makes the Riviera, from Cannes to San Remo, its winter residence, carriage driving is naturally a favorite pleasure; the excellent French highways are therefore appreciated, and they are undoubtedly among the principal attractions to tourists. We found the "Rue de la Corniche" in Marseilles the favorite carriage drive, and from Nice to Mentone the drive over the "Corniche Road" is considered the finest in all Europe. This road is about 20 miles long and was built by Napoleon I. The return from Mentone is over an equally well constructed road, skirting the Mediterranean, and leads through Monte Carlo, where an hour is usually spent in "doing" the Casino, its gambling tables within and its extremely beautiful gardens without; thence on past Monaco and to Villefranche, where 13 of the best French naval vessels lay at anchor during "the season"; through Beaulieu, the winter residence of Lord Salisbury, and soon after to Nice, the entire length of road being one of the very best of the French national highways.

The repairs are, of course, on the continuous plan of immediate attendance; the small squads of men, in uniform, and each duly labeled to show what his part of the work was, with necessary tools, carts and horses, were in evidence at very short intervals; road metal was in piles by the roadside every few yards, and the surface was kept equally free of dust and mud by judicious sprinkling.

We cannot now think of any other 20 miles of country highway more frequented by wheeled vehicles, including motor vehicles, pedestrians and cyclists, than that favored bit between Nice and Monte Carlo; the wonder is that the government is not tempted to exact a toll, even if a very small one.

Immediately one crosses the boundary at Ventimiglia, the poverty of Italy is thrust upon you; the roads are rough, out of repair, dusty or muddy, and carriage driving is confined to the city streets and immediate vicinity. As one ascends the mountains the roads become impassable except to pedestrians and the sure-footed donkey; transportation of merchandise, fuel, lumber, hay and other commodities is carried on by donkeys—and women—these latter beasts of burden being everywhere in evidence along the rough and narrow mountain roads, carrying on their backs or heads loads of most incredible size, although of light substances. All through Italy the male population has been drafted into the army of soldiers or priests, with which the towns and cities swarm; or they are cab drivers or fruit venders—anything that is easy—and if these occupations are not available they sit about the wine shops or cafes, or anywhere except where there is hard work to be done.

One never sees a plow or any other agricultural implement except a heavy spade or hoe, these mostly wielded by the women, or boys not yet of age to be conscripted.

The cultivated areas are slowly dug over with the spade. In the few cultivated fields on the Campagna, near Rome, large gangs of women and boys were weeding the grain with hoes; in Germany they progressed on all fours, weeding with their hands. Every available yard of arable land in Italy seemed to be utilized; the evidences of centuries of patient industry are always in sight.

The olive tree seems to be capable of living on the most meager soil; the most barren of rocky mountain sides were frequently clothed to the top with this monotonous tree, which is always in leaf, and apparently always in fruit—a small black berry used for making oil only, not the large green olive we use for a relish. To obtain level ground for the cultivation of the olive, the orange, lemon, fig tree, and flowers, the mountains along the Riviera are terraced, sometimes to the very summit; these terraces are evidently the work of many centuries of labor, and they are still being made; hence farming is largely an engineering operation; there is more masonry than digging or ploughing, and it involves leveling, besides providing a water supply. It is quite understandable why these narrow terraces should be cultivated only with mattock and hoe, but when one sees a few men and women digging over acres of flat alluvial lands one must feel some curiosity to know why the ordinary plow is ignored.

The streets of Italian cities are kept very clear of horse droppings, because everything of a manurial nature is in demand for these sterile hillsides. On a climbing trip up Mount Bignone, the highest peak in the vicinity of San Remo, I was well up the mountain side on the narrow and rough donkey road when I met a man carrying on his head a small basket partly filled with the droppings from the donkeys which alone could navigate the trail; it was the most striking illustration of the fierce struggle for subsistence which I have met in any country.

The taxes are quite beyond American imagination. Scarcely anything escapes the vigilant Treasury Department. If a merchant hangs in his window an advertisement of some special article he may have for sale, there is a revenue stamp on it in payment of the tax on advertisements. If a farmer has a fatted pig ready for killing, he pays a tax of six lire for the privilege of converting said animal into pork for consumption. How much he pays as "octroi" duty on fetching it to market I do not know. I paid a "sur-tax" of 9 lire on each of my Italian circular tickets. The tax on petroleum is 48 centimes per kilo., or three times its original value; the consequence of this tax is that its use as an illuminant is decreasing in favor of acetylene gas, which is not any more expensive and the home production of which is free from taxation. Another consequence is the prosperity of the stockholders of acetylene gas companies at the cost of the National Treasury. The par value of the stock of the Acetylene Gas Co. of Rome is 250 lire per share, and it has advanced to 1,040.

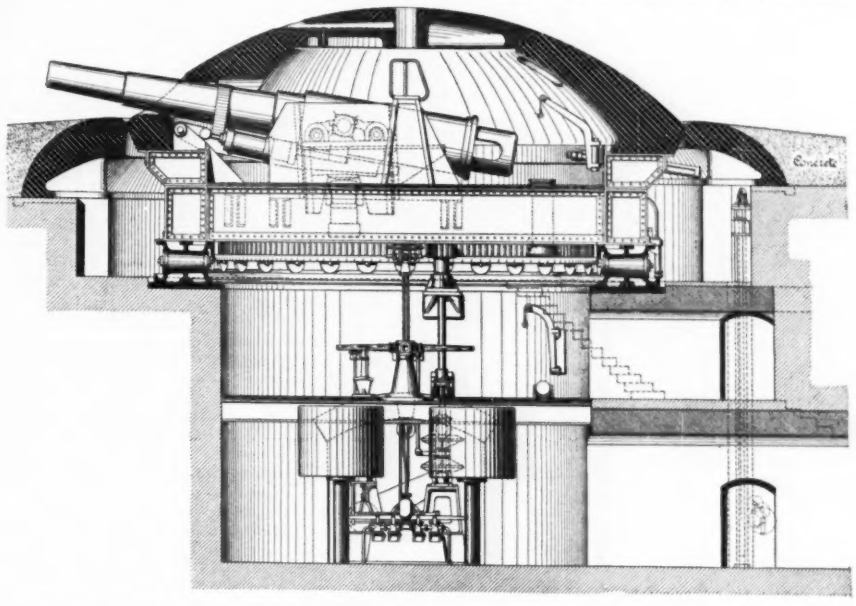
It would be interesting to know the amount of money left in Italy by tourists. A man, in my hearing, complaining of the excessive cost of railway travel, explained it on the ground that no Italian of any social or commercial influence ever paid railway fare; he and his family and relatives traveled on "free passes," to make up for which the tourist was taxed out of all decency. But the English speaking tourist swarms on the Riviera and throughout Italy. The female tourist largely outnumbers the stronger sex, and the smart, tailor-gowned, well-shod young English woman, Baedeker and camera in hand, is in evidence wherever there is anything interesting to be seen. In the best hotels a large population of the guests are English speaking. The masterfulness of the Anglo-Saxon is never more evident than in these Latin countries. It is no wonder that the enormous interest in southern France and in Italy that is practically dependent for its subsistence on the coming of the English and American tourist, should be alarmed over any stories set afloat in the season to turn this golden tide in other directions. Hence, when the English papers reported a prevalence of typhoid fever in Nice, last February, the city government, the British consul, resident physicians, civil engineers and other interested parties were immediately vehement in denials of any alarming extent of the disease, and the stories of defective sewerage were denied as strongly. So far as I could see, the sewerage of Nice is very fair. There are, however, a great number of cesspools still existent and a small steam "odoriess excavating" plant at work in front of residences is a frequent sight; the cesspool is located in the usually very small back yard. It is covered with a very close fitting stone, flush with the pavement; the excavating hose is hauled through the most accessible part of the house, wareroom or office, and the cesspool is soon emptied, with an almost total absence of offensive odor. Wherever the sewers are built they take everything from house and street. The outlets into the Mediterranean are at a few hundred yards from the shore, and are especially noticeable by the flocks of sea fowl always feeding on the surface above them. G. H. F.

Notes and Queries

The name and present address of Mr. Robert Hall Tyler, a contractor, or member of a contracting firm, is desired by W. H. Stokes, Esq., of Welch, W. Va.

THE GRUSON CHILLED CAST-IRON ROTATING TURRET FOR COAST FORTIFICATIONS.

The possible adoption of the Gruson revolving turret for mounting the great 16-in. coast defense gun now approaching completion at the Watervliet Arsenal, makes a description of this device of especial interest at the present time. As some of our readers may recall, this gun is to be located at Romer Shoals, at the entrance to New York Harbor, which is an exposed position for which the Gruson turret is considered to be especially adapted. Should this mounting be adopted here, it will be its first installation in the United States, although it has been frequently employed in European countries. The manufacture of the turret and the methods for making the chilled cast-iron armor used in its construction are controlled by the Krupp Iron Works, of Germany, which have disposed of the rights for America to the Gruson Iron Works, a company recently organized under a charter from the State of New York. This company proposes to establish works for the manufacture of the turret and armor, and is now seeking a suitable location somewhere on tidewater, where the enormous armor plate castings of 100 tons weight and more can be handled directly on shipboard.



GRUSON CHILLED CAST-IRON ROTATING TURRET FOR COAST FORTIFICATIONS.
Gruson Iron Works, New York, N. Y.

The Gruson turret is of the same general style for all sizes of coast defense rifles, but it, of course, varies in size, weight and power, to suit the dimensions of the gun which it protects. The accompanying cut shows this standard construction. Briefly described, the turret consists of a dome-shaped superstructure of armor plates mounted on a substructure of steel plate construction somewhat like the drum and turntable of a modern swing bridge. Large steel beams cross the drum to support the carriages on which the gun is mounted. The bottom edge of the drum rests on a ring of cone rollers, with collars like a spool, which runs on a track secured to the masonry. To protect the substructure the dome is surrounded by a ring of glacis armor imbedded in concrete masonry. This glacis armor ring is stationary, but the dome, of course, revolves on the roller ring. The power for revolution may be obtained from any kind of motor desired, steam being usually employed for the larger sizes of turrets. This motor is placed in the lower gallery and operates a vertical shaft having at its end a pinion, which gears with a rack on the inside of the circular drum. A capstan is provided for operating the turret by hand in cases of emergency, and there is also an arrangement for braking the turret to control its movements and to lock it in position. A hoist and hydraulic ram are provided for loading the gun.

The dome is perforated by two port holes, from which protrude the guns, and which so closely surround them that no projectile from the outside can penetrate into the interior of the turret. In order to make this possible the guns are mounted on special carriages, technically known as Gruson Minimum Port Carriages, which provide for the elevation and depression of the gun from a pivot near the center of the embrasure instead of having these movements take place on the trunnions of the gun. Such an arrangement makes it necessary to lift a considerable weight with every change in the elevation of the gun, and this is provided for by means of hydraulic accumulators which are kept in action by a special set of high pressure pumps. The traversing of the guns is effected by rotating the turret, the amount of such rotation necessary to a proper sighting being regulated by the commanding officer, who has his station in the center of the cupola, and makes his observations through an orifice in the dome or roof, which also contains a sighting apparatus.

The defensive feature of the turret is, of course, the armor plate dome. The plates which make up this dome are of a special quality of cast-iron, hardened by a surface chilling to a considerable depth. These plates or segments are double-curved sections, and are held together with steel keys. Two half-circular plates are employed for the roof, but the number of circumferential plates differs according to the dimensions of the dome. The thickness of the plates differs, but reaches a maximum of 60 ins., and the weight often reaches 100 tons for a single plate. The total weight of the complete turret is sometimes 2,000 tons. As will be seen, the exterior surface of the dome is so designed as to deflect the projectiles, and break them up by receiving the blow on the side instead of the point of the projectile. The capacity of this chilled cast-iron armor to resist the attack of projectiles when it is employed in the position described has been shown by numerous tests made in Europe.

For the information from which this description has been prepared we are indebted to the Gruson Iron Works, of 31 Nassau St., New York.

A SEWAGE DISTRIBUTING TANK AND AUTOMATIC DOSING APPARATUS FOR MARION, IA.

By F. A. Barbour.*

The recent developments in the bacterial treatment of sewage and the increased knowledge of the conditions essential to the life of the organisms upon which the process depends, are everywhere directing the attention of sanitarians to the possibilities of higher rates in sewage disposal.

*Of Snow & Barbour, Civil and Sanitary Engineers, Tremont Building, Boston, Mass.

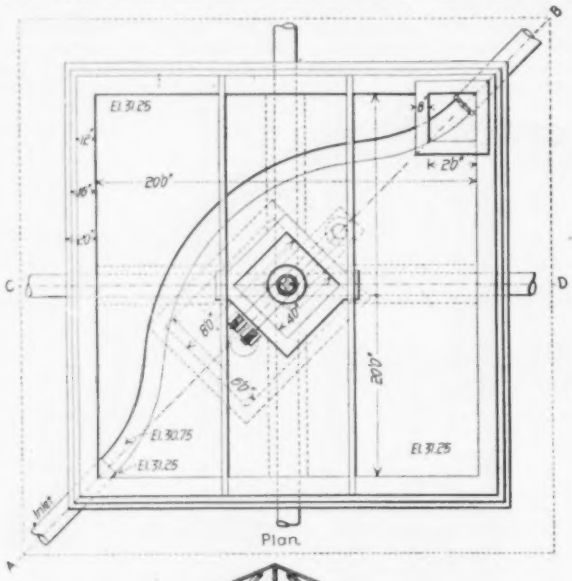
From the practical standpoint of the engineer, bacteria may be divided into two classes, aerobic and anaerobic. The latter, or putrefactive microbe, is utilized in the "glorified cesspool," or, as it is called in England, the septic tank; but whatever the preliminary process, whether biological or chemical, the final treatment of the sewage where a high degree of purification is demanded must be aerobic, and conditions suitable to the life of the nitrifying bacteria must be furnished. These conditions involve the presence of a sufficient amount of oxygen for the support of "Nature's scavengers" and the retention of the sewage in the "wet process crematory" for a time sufficient to effect purification. Such conditions are most easily obtained by applying the sewage to beds of porous material, such as sand, coke, burnt clay or ashes. With sand and fine coke the sewage is prevented from passing too quickly to the underdrains by the friction of the bedding material, and is consequently subjected to the attack of the microbes for a time sufficient to effect purification without closing the underdrains. In the case of coarse coke, ashes and burnt clay, however, it is necessary to shut the effluent gates until the desired quantity of sewage has been applied to the beds, and then by opening these gates to permit the escape of the effluent. In either case intermittency is a sine qua non, supplied in the first method by dividing the raw sewage into suitable doses, and in the second by permitting the effluent to escape in quantities determined by the open space of the material used in the beds.

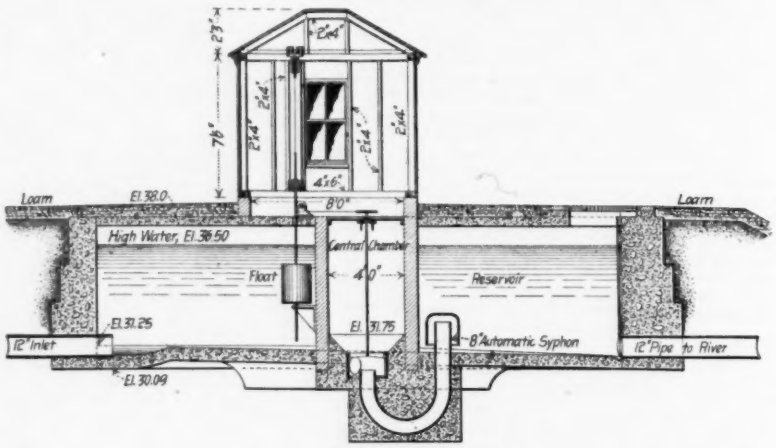
It is necessary, in order that sufficient air for the life of the microbes may enter the body of the filter, that the sewage be shifted from one bed to the next, and the arrangement illustrated on the accompanying plan is intended to effect automatically the application of the sewage in doses suitable to the sand, or whatever material is used, to four beds in turn.

High rates in sewage disposal are becoming possible, because of the better understanding by sanitarians of the reactions, and the conditions essential to their fulfilment, by which Nature has, since time began, removed the off-scourings of life and transformed them into harmless mineral products. Except in favored localities, however, natural conditions have not been supplied in the ratio necessary to effect purification of the concentrated off-scourings of man, due to his gathering in communities. Where suitable soil deposits naturally exist, intermittent filtration or irrigation—both of which are bacterial processes—are economical and efficient methods of sewage disposal, and in such cases, if the depth of soil is sufficient and land cheap, small rates per acre are feasible, and no great refinement in methods of applying the sewage is necessary. Where natural deposits of suitable soil cannot be found, and beds must be artificially constructed, then it becomes economical to employ high rates. When this is done the bedding material must be more carefully studied, and the application of the sewage equated to its capacity, as determined by mechanical analyses, in doses suitable to the highest development of the organisms, and in such a way that the passage of the sewage through the bedding material will not be so rapid that purification cannot be effected.

It is thus apparent that the labor necessary for the successful operation of high rate filters is a considerable factor in their use. The material must be coarse, in order that the liquid can pass through; the dose must, consequently, be frequent and small, in order that the rates may be high and that oxygen in ratio of the applied sewage may enter between doses, and also that the sewage may not pass too quickly under a head. Another factor increasing the labor in operating high rate filters is the necessity of limiting the size of the filter to the rate of application, and the consequent division of the field into small areas when the dose is to be small. In short, automatic application of the sewage seems essential to the economical utilization of high rates in sewage disposal.

The accompanying plan and sections illustrate a distribution tank of a capacity equal to the size of dose suitable to the material and area of the bed, and an automatic apparatus by which the discharge of the sewage is changed from one bed to the next. The sewage enters the reservoir, and when it reaches a certain height, is discharged by the automatic siphon into the small central chamber, which, until the discharge of the siphon, remains empty—the lower leg of the siphon entering this chamber in the center of its bottom. In the bottom of this central chamber, and surrounding the discharge end of the siphon pipe, is placed a cast-iron cylinder machined on its inner face, with four openings in its circumference connecting with four outlet pipes laid under the floor of the reservoir, and leading to four filter beds. Inside of this cylinder, and closely fitting it, another cylinder, with one opening in its circumference, is supported and revolved by a vertical shaft, to the top of which a horizontal pulley is attached by a ratchet or friction clutch.

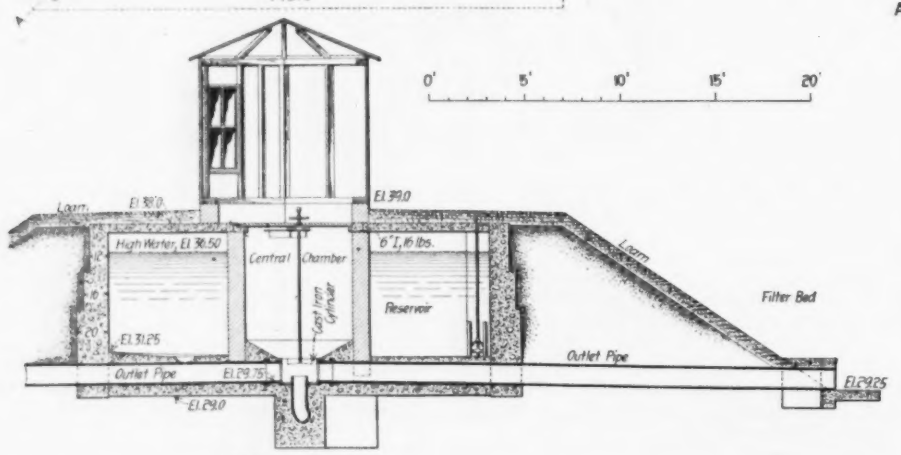




Section A–B.

DISTRIBUTING TANK AND AUTOMATIC DOSING APPARATUS FOR SEWAGE PURIFICATION WORKS.

F. A. Barbour, Engineer.



Section C–D

A float moving in guides is placed in the outer reservoir, and with the rise of the sewage the float is lifted a certain distance, carrying with it a rod which runs up through the floor of a small house, and to which is attached a wire rope guided by pulleys and connected with the horizontal pulley already mentioned. The float is permitted to rise a distance just sufficient to revolve this pulley, and with it the vertical rod and inner cylinder, 90°, thus shifting the opening in the inner cylinder from in front of one outlet pipe to the next. The weight of the float in dropping back, with the discharge of sewage through the siphon, throws the horizontal pulley back 90°, to be ready for the next rise, this movement being on the reverse action of the friction clutch, and consequently without effect on the four-way gate or revolving cylinder.

Thus the rise and fall of the sewage, as made possible by the siphon, will automatically apply the sewage in rotation to four beds. The vertical shaft is provided with a square head, so that, should accidents occur, which is unlikely, owing to the extreme simplicity of the apparatus, the four-way gate may be moved by hand.

The distribution reservoir and apparatus, such as described, will cost less than $1,000, and it only needs a very limited calculation to show its economy. It is valuable, however, not only as a labor-saving device, but in the guarantee it affords of absolute regularity in the application of the sewage and the assurance that the best possible results will be obtained from the nitrification beds.

For small plants, not large enough to justfy the attendance of one man, or for larger disposal fields, by the construction of more than one of these arrangements, this design is valuable.

The apparatus described was designed for a small sewage purification plant at Marion, Ia., for which plans have been made by the firm of which the writer is a member. It is expected that these plans will be carried out during the coming

summer, as several riparian owners below the town have brought suits for damages on account of alleged pollution of the stream into which the sewage is discharged. An outline of the proposed plan of sewage treatment will serve to show still further the manner in which it is expected the dosing apparatus will be used, as well as the advantages of some such device. Marion, the county seat of Linn Co., Ia., is a city with a population now estimated at 5,000, having increased to this figure from 1,939 in 1880, and 3,094 in 1890. It is situated on Indian Creek, a tributary of the Cedar River. A public water supply was introduced in 1884-5 by a private company, and a partial system of sewers some time prior to 1890. The business and more thickly-settled portion of the town, which is the section already sewered, is at such an elevation that the sewage can be intercepted and flowed by gravity onto beds at a sufficient height to avoid floods in Indian Creek. The sewage from this portion of the town is, accordingly, to be intercepted at such an elevation as will make possible a gravity outfall, and the remaining low-lying territory will, when the necessity arises, be furnished with a low area interceptor, discharging into a small tank, from which it will be lifted automatically into the higher interceptor. The gravity outfall sewer is to flow into a decomposition reservoir, or, as it is more generally called, a septic tank, with a capacity of 150,000 gallons, built entirely of concrete, except in the case of the piers and lintel arches.

The outfall sewer enters a gate chamber provided with gates, by which the sewage can be turned either into the reservoir or directly to the beds or river. The inlets to the reservoir are trapped; the outlet is composed of vitrified channel pipe, placed on a bracket built of concrete and covered with another inverted channel pipe, so arranged as to leave a narrow opening or slot for the escape of the sewage, this slot being at a depth of 3 ft. below the surface of the sewage in the reservoir.

The decomposition reservoir is so planned that it can, by the opening of a gate, be entirely emptied should necessity arise. The reservoir is designed to be completely air-tight.

The effluent, after passing through the slotted pipe, flows through vertical risers to an overflow weir, and then falls 3 ft., for the purpose of aeration, in a chamber built across the end of the reservoir and containing three manholes with perforated covers. The effluent then flows into a manhole from which the pipe which enters the distribution tank at the bottom carries it to the beds, upon which it is flowed by the automatic apparatus. The filling of the distribution tank floods the effluent to the level of the bottom of the aeration chamber. The curved invert shown on the bottom of the distribution tank is for the purpose of carrying the raw sewage directly to the river, without the probability of lodgment of the suspended matter of the sewage in the distribution tank.

An overflow is arranged from the gate chamber in which the outfall sewer ends, and also from the manhole into which the effluent from the septic tank passes, and it is, therefore, possible to either apply raw sewage directly to the beds or to the river, or to flow the effluent from the decomposition reservoir into the river.

The distribution tank is to be situated at the intersection of the embankments dividing the disposal field into four filter beds, each 125 ft. sq. The sand of which the filters are to be constructed is to be obtained from the river deposits along Indian Creek. The particular deposit recommended for use has an effective size of 0.6mm. (0.0024-in.), a coefficient of uniformity of 3.0, iron 0.50 parts per 100,000, and carbonates 0.34 parts. All sand will have to be hauled a considerable distance to the beds, artificially constructed. The material is coarse enough to make possible high rates, and with the dosing which the use of the distribution tank and automatic apparatus guarantees, should at all times furnish a good effluent.

The nitrification beds are designed to work at the rate of 150,000 gallons per acre, and it is believed that considerably higher rates will be possible, in consideration of the fact that either raw sewage or effluent from the decomposition reservoir can be turned directly into the stream, and the disposal plant can be operated with due relation to the available dilution from the run-off of the stream, at a much higher average yearly rate than that estimated in the design, without the creation of any nuisance.

TEST OF MECHANICAL FILTER AT EAST PROVIDENCE, R. I.

By Edmund B. Weston, M. Am. Soc. C. E., M. Inst. C. E.*

The following gives the results that were obtained during a test of 110 days of a mechanical filter that has recently been installed under the direction of the writer for the East Providence Water Co., at East Providence, R. I.

The New York Filter Mfg. Co., of New York, furnished the filter, which is of a type known as the Jewell gravity filter. The available capacity of the filter is 500,000 gallons per 24 hours, and the rate of filtration 125,000,000 gallons per acre per 24 hours. The filter was run throughout the test under ordinary working conditions, and the filtered water was pumped directly into the mains and supplied to the consumers. It was in charge, under the writer's direction, of the regular pumping engineer of the East Providence Water Co. The writer gave directions from time to time, but did not, on the average, visit the filter plant more than once a week during the test. The test was commenced on March 13, 1899, and completed on June 30.

The chemical analyses were made by Prof. John Howard Appleton, of Brown University. The bacteriological work was done by Dr. Gardner T. Swarts, Secretary of the State Board of Health of Rhode Island, who also determined the color and alkalinity of the samples.

The chemical used during the test was sulphate of alumina. This was added to the raw water in the form of a coagulant solution, which was prepared by dissolving 1 part sulphate of alumina in about 20 parts of filtered water. The solution was always thoroughly mixed before being used.

The sulphate of alumina used during the test and special experiments, contained about 22% of Al_2O_3, with the exception of during two special experiments, when an inferior and cheaper grade, containing about 17.53% of Al_2O_3, was used. The sulphate of alumina was added to the raw water at the rate of 1 grain per gallon, with the exception of during four special experiments, when 0.75, 0.6, 0.75 and 1.25 of a grain per gallon was used.

The average of the chemical results obtained during the test, not including the special experiments, show the following percentages of reduction in the filtered water as compared with the raw water: Total solids, 6%; chlorine, 1%; ferric oxide, 61%; alumina oxide, 38%; free ammonia, 29%; albuminoid ammonia, 63%; color, 83%.

There was an increase of hardness in the filtered water of 20%. The filtered water in every instance was more or less alkaline.

The following table gives the bacteriological results that were obtained during the time that one grain of sulphate of alumina per gallon was used:

Bacterial Results Shown by the East Providence Mechanical Filter, When Using 1 grain of Sulphate of Alumina per Gallon and Operating at a Rate of 125,000,000 Gallons per Acre per 24 hours.*

Date.	Bacteria pr cu.cm. Raw wat'r.	Filtered wat'r	Reduction, %.
March 13.	768	4.0	99.48
" 14.	595	5.5	99.08
" 15.	Sterilized beds.		
" 16.	1,299	9.0	99.31
" 17.	1,257	7.0	99.45
" 18.	683	4.0	99.41
" 31.	782	1.5	99.82
April 1..	499	7.0	98.60
" 3..	636	1.5	99.76
" 4..	628	2.0	99.68
" 5..	545	4.0	99.27
" 6..	855	3.0	99.65
" 7..	1,910	19.0	99.01
" 8..	1,009	6.5	99.36
" 10..	1,175	6.5	99.45
" 11..	943	9.3	99.01
" 12..	1,443	9.0	99.38
" 13..	336	4.3	98.73
" 14..	Lost.	4.0	.....
" 15..	798	1.6	99.84
" 17..	765	7.5	99.02
" 18..	578	1.5	99.74
" 19..	865	11.0	98.73
" 20..	546	3.0	99.45
" 21..	699	2.0	99.71
" 22..	499	3.0	99.40
" 24..	293	3.0	98.98
" 25..	697	0.5	99.93
" 26..	724	11.0	98.48
" 27..	422	9.0	97.87
" 28..	280	2.5	99.11
" 29..	370	6.0	98.38
May 8...	266	9.0	96.62
" 9...	976	3.0	99.69
" 10...	708	13.5	98.09
May 11...	150	5.0	96.66
" 12...	466	3.5	99.25
" 13...	305	4.0	98.69
" 15...	225	1.0	99.56
" 16...	238	0.5	99.79
" 17...	306	0.5	99.83
" 18...	473	0.0	100.00
" 19...	210	0.5	99.76
" 20...	228	1.0	99.56
" 22...	238	0.5	99.79
" 23...	279	1.0	99.64
" 24...	228	1.0	99.56
" 25...	275	0.0	100.00
" 26...	270	0.5	99.81
" 27...	185	1.0	99.46
" 29...	454	4.5	99.01
" 30...	334	11.5	96.56
" 31...	458	10.0	97.82
June 8...	331	4.0	98.79
" 9...	494	5.6	98.86
" 10...	341	6.3	98.15
" 12...	354	0.3	99.92
" 13...	243	2.0	99.18
" 14...	181	0.3	99.83
" 15...	265	1.0	99.62
" 16...	388	0.6	99.85
" 17...	277	1.3	99.53
" 19...	Lost.	9.0	.....
" 20...	233	8.0	96.56
" 21...	291	4.3	98.52
" 29...	2,096	4.0	99.81
" 30...	849	4.0	99.53
Av'ge.	570	4.3	99.24

*Special experiments were made from March 20 to 30, from May 1 to 6, from June 1 to 7, and from June 22 to 28. The bacteria in the different samples were cultivated during periods of from five to six days.

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As can be seen by the table, there are 64 results; the average percentage of removal is 99.24, the lowest 96.56, and the highest 100%.

The total number of percentages below 96.56 is 0; below 97 is 4; below 98 is 6; below 99 is 18.

Attention is called to the fact that the preceding summary of results shows that the filtered water contained 38% less alumina than did the raw water before the sulphate of alumina was added to it.

The results given in the table are remarkably satisfactory; but on account of several instances when the bacterial percentages of reduction are shown to be below 98%, the writer would state that the filter has been working at a disadvantage for a comparison by percentages, on account of the small number of bacteria in the raw water.

As can be seen by the table, the average number of bacteria found in the filtered water is less than 4½ per cu. cm., which is a remarkably small number (the average number found in the effluent of the Lawrence city filter during March and April, 1898, being 28). Therefore, if the results given in the table should be used for comparison with results obtained with other filters, the small number of bacteria found in the filtered water should be duly taken into consideration, as well as the percentages of reduction.

The disadvantage under which the filter has been working, is in accordance with the supposition, that a few bacteria may, at times, grow in a filter and be carried through the same during the process of filtration. These few bacteria would, in ordinary practice, be counted among others found, if there were such, in the filtered water.

Now, if there were 2,000 bacteria per cu. cm. in the raw water, and a small number per cu. cm. should grow in the filter, they would not appreciably affect the percentage of reduction, owing to their number being relatively very small in comparison with the number in the raw water. If, however, the number of bacteria that grew in the filter was the same, and there should be 200 or 300 per cu. cm., for instance, in the raw water, instead of 2,000, the percentage of reduction might be considerably affected, as the small number that grew in the filter might bear an appreciable proportion to the 200 or 300 in the raw water.

The average removal of bacteria during the entire test, including the special experiments, was 98.87%. During the special experiments, as has already been mentioned, two grades of sulphate of alumina and 0.75, 0.6, 0.75 and 1.25 grains per gallon were used.

THE FIRING OF HIGH EXPLOSIVES from large caliber guns was tested at the Sandy Hook proving grounds on July 12 by the Board of Ordnance and Fortification of the U. S. Army. The first test consisted in firing a charge of 115 lbs. of explosive gelatin inclosed in an Isham Diaphragm steel shell from a 12-in. gun of the ordinary service pattern loaded with 415 lbs. of brown powder. The shell left the gun safely and ricochetted several times on the water without exploding. Another test was made, using thorite as the explosive. This was placed in service shells and was fired from an 8-in. gun. The bursting charge varied, but when the armor-piercing shells were used it was about 12 to 13 lbs. The shells were fired through 4½-in. steel, and, while the plate was shattered, the charge did not explode. The ordnance officers who witnessed the tests are reported as saying that never before have such charges of high explosives been fired from service guns. A supplemental test made at the same time as were these, was the testing of the Lewis range finder, to determine if it were affected by the concussion of guns fired close by. The tower carrying the range finder was located 100 yds. from the battery of 12-in. guns, which were fired twice without producing any effect upon the instrument.

A CONCRETE AND STEEL PARAPET for fortifications has been suggested by Gen. R. A. Alger, Secretary of War, and an experimental parapet has been built for test. Steel rails are imbedded in the concrete, and it is claimed that this construction will be stronger than the ordinary concrete parapets protected by earthwork.

THE STRENGTH OF COKE CONCRETE as compared with that of broken stone concrete is given as follows in the report of some tests made by Mr. Wm. H. Vance and described in the "Technograph" of the University of Illinois:

Proportions.	Strength of Portland cement concrete. —Coke.— No. tests.	Lbs. per sq. in.	—Broken-stone.— No. tests.	Lbs. per sq. in.	——Weight, lbs. per cu.ft. Broken Ratio.	Coke.	stone.	Ratio.
1:3:5	12	610	3	1,351	1:2:2	92	139	1:1:5
1:3:6	3	635	3	877	1:1:4	81	137	1:1:7

The experiments consisted in testing sixty 6-in. cubes which were broken at ages of 30, 60 and 90 days. The coke was broken by hand to pass a 1¾-in. ring, and it contained 90% voids. No difference in strength was observed between gas retort coke and coke oven coke, but a few tests made to determine the difference between dry coke and

wet coke seemed to show that the dry coke give results about 30% higher. Referring to the figures given in the table it will be seen that, taking the averages, coke concrete is about 40% lighter in weight and 45% weaker than broken stone concrete of the same proportions.

A NEW IMPACT TESTING MACHINE for testing paving brick has been designed by Mr. Gomer Jones, City Engineer, of Geneva, N. Y., in which the bricks are held securely clamped around the inner periphery of the barrel. The barrel holds 32 bricks, which have one face exposed to the abrading material, which consists of 150 lbs. of steel-chilled iron cubes. The chief merits of this machine have been pointed out to be (1) that it simulates actual conditions of service better than the methods heretofore used; (2) that it will probably give more uniform and more easily standardized results, and (3) that specimens of different manufacture may be readily tested at a single operation with results that are truly comparative.

THE HOLDING POWER OF ANCHOR BOLTS has been made the subject of some tests by Mr. M. M. Wilcox, who summarizes the results in a paper published in the "Technograph" of the University of Illinois. These experiments were made upon the holding power of bolts fastened with cement, lead and sulphur. Holes 1¼ ins. to 1⅝ ins. in diameter were drilled in hard limestone blocks about 6 ins. thick. About one-half of the bolts were 1 in. in diameter, and the others were ¾-in. in diameter. Smooth, threaded and notched bolts were used. The smooth and notched rods always drew out of the cementing material; the threaded bolts sometimes pulled out of the lead and sometimes pulled the lead out of the hole, and always pulled out the cement and sulphur. A good cement was mixed to a grout or plastic mortar, and rammed around the rods. After standing for seven days the mean of twelve experiments with smooth bolts gave a resistance to pulling of 166 lbs. per sq. in. of surface of contact of bolt. Three experiments with notched rods gave a mean result after seven days of 336 lbs. per sq. in., two threaded rods gave 585 lbs. per sq. in. after seven days, and two gave 832 lbs. per sq. in. at the end of 14 days. With lead four smooth rods gave 832 lbs., one notched rod gave 460 lbs., and six threaded rods gave 903 lbs. per sq. in. With sulphur the threaded rods gave a resistance of 1,502 lbs. per sq. in., a mean of seven experiments, one notched rod gave 328 lbs. and one smooth rod 200 lbs. per sq. in.

THE SCHERZER ROLLING-LIFT BRIDGE, which is to carry the tracks of the New York, New Haven & Hartford R. R. across Fort Point Channel, at Boston, has been partially tested. One of the three double-track arms has been operated successfully. In ordinary service the three parts will be operated as one bridge, the average time of opening the bridge being 50 seconds.

A NEW CHAIN FOR POWER TRANSMISSION and for use in elevators and conveyors has recently been developed by the Aultman Co., of Canton, O., in which the wear and strain at the joints is chiefly taken by a renewable sleeve which bears at its ends in sockets in the side bars. The bolts at the joints are thus in great measure relieved from strain and wear. Chains of this type are furnished in single strands for working strains of 3,000 lbs. to 12,000 lbs., and by working in double strand higher strengths may be reached.

THE INCLINE RAILWAYS at Pittsburg, Pa., are eleven in number, all being double track lines operated by cables, the ascending and descending cars balancing one another. Most of them are for passengers and teams, some carry street cars, and one has two double tracks, of which one is for passengers and the other for wagons. These inclines are as follows: (1) Fort Pitt incline, 350 ft. long, capitalized at $60,000; (2) Monongahela incline, double, 640 ft., $240,000; (3) Pittsburg & Castle Shannon incline, 2,112 ft.; (4) Pittsburg incline, 2,000 ft., $150,000; (5) Mount Oliver incline, $100,000; (6) St. Clair incline, 1,320 ft., $150,000; (7) Duquesne incline; (8) Penn incline, $200,000; (9) Nunnery Hill incline, $60,000; (10) Troy incline, 370 ft., $200,000; (11) Clifton Park incline.

MOTOR VEHICLES MAY BE USED IN THE PARKS of Chicago, notwithstanding the prohibitive order of the South Park Commissioners. Judge Gibbon, in giving this decision, is reported as saying that "it is a matter of common knowledge that there is less danger in an automobile than in a horse and buggy."

THE VALUATIONS OF THE DUBUQUE WATERworks, submitted by various engineers to the board of appraisement, were as follows: John W. Hill, $664,076; John W. Alvord, $710,513; John T. Fanning, $684,553; Daniel W. Mead, $693,460; Geo. H. Benzenberg, $691,668. These estimates were made by the engineers called by the company and average about $639,000. A joint estimate of $485,733 was submitted by the four engineers called by the city, Messrs. W. Kiersted, W. S. McHarg, Samuel G. Artingstall, and Chas. C. Chase. The company introduced testimony to show that the original cost of the works, not including improvements now under contract, was $559,000. The difference in the estimates was chiefly on the value of the property as a going concern, a source of water supply and the amount to be allowed for depreciation. It is likely to be some weeks before the valuation is fixed by the board of appraisement, the members of which were given in our issue of June 20.

PLANS FOR THE LOCATION OF THE LOCKAWAY river dam for the new water supply of Jersey City have been submitted to the Street and Water Commissioners by the contractor, Mr. P. H. Flynn, 187 Montague St., Brooklyn. Explorations show the necessity of locating the dam higher up the river than was originally proposed. Mr. Garwood Ferris is Engineer in charge of the new supply on behalf of the city.

THE AMOUNT OF WATER USED IN IRRIGATING different crops in 15 states is now being investigated by the U. S. Department of Agriculture by Mr. Elwood Mead, M. Am. Soc. C. E., of Cheyenne, Wyo. Other irrigation problems are also being studied under his direction.

THE NEW ORLEANS SEWERAGE CO. has been awarded $90,000 by a jury in a suit against the American Surety Co., of New York. The latter company went on the bond of Steward & McDermott, contractors for a portion of a sewerage system for New Orleans. The amount of the contract was about $181,000 and the amount of the bond, $100,000. The contractors began work, but afterwards abandoned the job. A motion for a new trial has been made, failing which it is expected that an appeal will be taken. The Sewerage Co. never completed much work and a suit for the forfeiture of its franchise is now pending. Mr. A. A. Woods has been receiver of the company for some time.

BIDS FOR SEPTIC TANKS AND SEWAGE FILTER beds at Independence, Mo., are to be received by Mr. H. H. Pendleton, City Engineer, on July 18. The estimated cost is $40,000.

STANDARDS FOR ELECTRICAL APPARATUS.

Two years ago the American Institute of Electrical Engineers appointed a committee to prepare a set of standards for electrical apparatus for the use of consulting engineers, manufacturers and others. A preliminary report was presented a year ago, and the final report was made at the recent Boston Convention of the Society. The high professional standing of the members of the committee adds great weight to their conclusions; and their report will be preserved for permanent reference by every one interested in electrical engineering. We reprint it in full below:

Your Committee on Standardization begs to submit the following report, covering such subjects as have been deemed of pressing and immediate importance, and which are of such a nature that general agreement may be expected upon them. While it is the opinion of the committee that many other matters might advantageously have been considered, as, for example, standard methods of testing, yet it has been deemed inexpedient to attempt to cover in a single report more than is here submitted. Francis B. Crocker, Chairman; Cary T. Hutchinson, A. E. Kennelly, J. W. Lieb, Jr., Charles P. Steinmetz, Lewis B. Stillwell, Elihu Thomson.

Electrical apparatus will be treated under the following heads:

I. COMMUTATING MACHINES, which comprise a constant magnetic field, a closed-coil armature, and a multisegmental commutator connected thereto.

Under this head may be classed the following: Direct current generators; direct-current motors, direct-current boosters, motor-generators, dynamotors, converters and closed-coil arc machines.

A booster is a machine inserted in series in a circuit to change its voltage, and may be driven either by an electric motor, or otherwise. In the former case it is a motor-booster.

A motor-generator is a transforming device consisting of two machines; a motor and a generator, mechanically connected together.

A dynamotor is a transforming device combining both motor and generator action in one magnetic field, with two armatures or with an armature having two separate windings.

For Converters, see III.

II. SYNCHRONOUS MACHINES, which comprise a constant magnetic field, and an armature receiving or delivering alternating currents in synchronism with the motion of the machine; i. e., having a frequency equal to the product of the number of pairs of poles and the speed of the machine in revolutions per second.

III. SYNCHRONOUS COMMUTATING MACHINES:—These include: 1. Synchronous converters; i. e., converters from alternating to direct, or from direct to alternating current, and 2. Double current generators; i. e., generators producing both direct and alternating currents.

A converter is a rotary device transforming electric energy from one form into another without passing it through the intermediary form of mechanical energy.

A converter may be either:

a. A direct-current converter, converting from a direct current to a direct current; or,

b. A synchronous converter, formerly called a rotary converter, converting from an alternating to a direct current, or vice versa.

Phase converters are converters from an alternating-current system to an alternating-current system of the same frequency but different phase.

Frequency converters are converters from an alternating-current system of one frequency to an alternating-current system of another frequency, with or without changes of phase.

IV. RECTIFYING MACHINES, OR PULSATING-CURRENT GENERATORS, which produce a unidirectional current of periodically varying strength.

V. STATIONARY INDUCTION APPARATUS; i. e., stationary apparatus changing electric energy from one form into another without passing it through an intermediary form of energy. These comprise:

a. Transformers, or stationary induction apparatus in which the primary and secondary windings are electrically insulated from each other.

b. Auto-transformers, formerly called compensators; i. e., stationary induction apparatus in which part of the primary winding is used as a secondary winding; or conversely.

c. Potential regulators, or stationary induction apparatus having a coil in shunt, and a coil in series with the circuit, so arranged that the ratio of transformation between them is variable at will.

These may be divided into:—

1. Compensator potential regulators, in which the number of turns of one of the coils is changed.
2. Induction potential regulators, in which the relative positions of primary and secondary coils is changed.
3. Magneto potential regulators, in which the direction of the magnetic flux with respect to the coils is changed.

d. Reactive coils, or Reactance coils, formerly called choking coils; i. e., stationary induction apparatus used to produce impedance or phase displacement.

VI. ROTARY INDUCTION APPARATUS, which consist of primary and secondary windings rotating with respect to each other. They comprise:

a. Induction motors.
b. Induction generators.
c. Frequency changers.
d. Rotary phase converters.

EFFICIENCY.

1. The "efficiency" of an apparatus is the ratio of its net power output to its gross power input.*

2. Electric power should be measured at the terminals of the apparatus.

3. In determining the efficiency of alternating-current apparatus, the electric power should be measured when the current is in phase with the E. M. F., unless otherwise specified, except when a definite phase difference is inherent in the apparatus, as in induction motors, etc.

4. Mechanical power in machines should be measured at the pulley, gearing, coupling, etc., thus excluding the loss of power in said pulley, gearing or coupling, but including the bearing friction and windage. The magnitude of bearing friction and windage may be considered as independent of the load. The loss of power in the belt and the increase of bearing friction due to belt tension, should be excluded. Where, however, a machine is mounted upon the shaft of a prime mover, in such a manner that it cannot be separated therefrom, the frictional losses in bearings and in windage, which ought, by definition, to be included in determining the efficiency, should be excluded, owing to the practical impossibility of determining them satisfactorily. The brush friction, however, should be included.

a. Where a machine has auxiliary apparatus, such as an exciter, the power lost in the auxiliary apparatus should not be charged to the machine but to the plant consisting of machine and auxiliary apparatus taken together. The plant efficiency in such cases should be distinguished from the machine efficiency.

5. The efficiency may be determined by measuring all the losses individually and adding their sum to the output to derive the input, or subtracting their sum from the input to derive the output. All losses should be measured at, or reduced to, the temperature assumed in continuous operation, or in operation under conditions specified. (See Sections 25 to 31.)

In order to consider the application of the foregoing rules to various machines in general use, the latter may be conveniently divided into classes as follows:

1. COMMUTATING MACHINES.

6. In commutating machines the losses are:

a. Bearing friction and windage. (See Section 4.)

b. Molecular magnetic friction, and eddy currents in iron and copper. These losses should be determined with the machine on open circuit, and at a voltage equal to the rated voltage + I r in a generator, and — I r in a motor, where I denotes the current strength, and r denotes the internal resistance of the machine. They should be measured at the correct speed and voltage, since they do not usually vary in proportion to the speed or to any definite power of the voltage.

c. Armature resistance losses. $I^2 r'$, where I is the current strength in the armature, and r' is the resistance between armature brushes, excluding the resistance of brushes and brush contacts.

d. Commutator brush friction.

e. Commutator brush-contact resistance. It is desirable to point out that with carbon brushes the losses (d) and (e) are usually considerable in low voltage machines.

f. Field excitation. With separately excited fields, the loss of power in the resistance of the field coils alone should be considered. With shunt fields or series fields, however, the loss of power in the accompanying rheostat should also be included, the said rheostat being considered as an essential part of the machine, and not as separate auxiliary apparatus.

(b) and (c) are losses in the armature or "armature losses;" (d) and (e) "commutator losses;" (f) "field losses."

7. The difference between the total losses under load and the sum of the losses above specified, should be considered as "load losses," and are usually trivial in commutating machines of small field distortion. When the

*An exception should be noted in the case of storage batteries or apparatus for storing energy, in which the efficiency, unless otherwise qualified, should be understood as the ratio of the energy output to the energy intake in a normal cycle.

field distortion is large, as is shown by the necessity for shifting the brushes between no load and full load, or with variations of load, these load losses may be considerable, and should be taken into account. In this case the efficiency may be determined either by input and output measurements, or the load losses may be estimated by the method of Section II.

8. Boosters should be considered and treated like other direct-current machines in regard to losses.

9. In motor-generators, dynamotors or converters, the efficiency is the electric output divided by the electric input.

II. SYNCHRONOUS MACHINES.

10. In synchronous machines the output or input should be measured with the current in phase with the terminal E. M. F., except when otherwise expressly specified.

Owing to the uncertainty necessarily involved in the approximation of load losses, it is preferable, whenever possible, to determine the efficiency of synchronous machines by input and output tests.

11. The losses in synchronous machines are:

a. Bearing friction and windage; see Sec. 4.

b. Molecular magnetic friction and eddy currents in iron, copper and other metallic parts. These losses should be determined at open circuit of the machine at the rated speed and at the rated voltage, + I r in a synchronous generator, — I r in a synchronous motor, where I = current in armature, r = armature resistance. It is undesirable to compute these losses from observations made at other speeds or voltages.

These losses may be determined either by driving the machine by a motor, or by running it as a synchronous motor, and adjusting its fields so as to get minimum current input and measuring the input by wattmeter. The former is the preferable method, and in polyphase machines the latter method is liable to give erroneous results in consequence of unequal distribution of currents in the different circuits caused by inequalities of the impedence of connecting leads, etc.

c. Armature resistance loss, which may be expressed by $p\ I^2\ r$; where r = resistance of one armature circuit or branch, I = the current in such armature circuit or branch, and p = the number of armature circuits or branches.

d. Load losses as defined in section 7. While these losses cannot well be determined individually, they may be considerable, and, therefore, their joint influence should be determined by observation. This can be done by operating the machine on short circuit and at full-load current, that is, by determining what may be called the "short-circuit core loss." With the low field intensity and great lag of current existing in this case, the load losses are usually greatly exaggerated.

One-third of the short-circuit core loss may, as an approximation, and in the absence of more accurate information, be assumed as the load loss.

e. Collector-ring friction and contact resistance. These are generally negligible, except in machines of extremely low voltage.

f. Field excitation. In separately-excited machines, the $I^2\ r$ of the field coils proper should be used. In self-exciting machines, however, the loss in the field rheostat should be included. (See Section 6 f.)

III. SYNCHRONOUS COMMUTATING MACHINES.

12. In synchronous converters, the power on the alternating-current side is to be measured with the current in phase with the terminal E. M. F., unless otherwise specified.

13. In double-current generators, the efficiency of the machine should be determined as a direct-current generator in accordance with section 6, and as an alternating-current generator in accordance with section II. The two values of efficiency may be different, and should be clearly distinguished.

14. In synchronous converters the losses should be determined when driving the machine by a motor. These losses are:

a. Bearing friction and windage, see section 4.

b. Molecular magnetic friction and eddy currents in iron, copper and metallic parts. These losses should be determined at open circuit and at the rated terminal voltage, no allowance being made for the armature resistance, since the alternating and the direct currents flow in opposite directions.

c. Armature resistance. The loss in the armature is $q\ I^2\ r$, where I = direct current in armature, r = armature resistance and q, a factor which is equal to 1.37 in single-phasers, 0.56 in three-phasers, 0.37 in quarter-phasers and 0.26 in six-phasers.

d. Load losses. The load losses should be determined in the same manner as described in section 11 d, with reference to the direct-current side.

e and f. Losses in commutator and collector friction and brush-contact resistance. See sections 6 and 11.

g. Field excitation. In separately-excited fields, the $I^2\ r$ loss in the field coils proper should be taken, while in shunt and series fields the rheostat loss should be included, except where fields and rheostats are intentionally modified to produce effects outside of the conversion of electric power, as for producing phase displacement for voltage control. In this case 25% of the $I^2\ r$ loss in the field proper at non-inductive alternating circuit should be added as proper estimated allowance for normal rheostat losses. (See Section 6 f.)

15. Where two similar synchronous machines are available, their efficiency can be determined by operating one machine as a converter from direct to alternating, and the other as a converter from alternating to direct, connecting the alternating sides together, and measuring the difference between the direct-current input and the direct-current output. This process may be modified by returning the output of the second machine through two boosters into the first machine and measuring the losses. Another modification might be to supply the losses by an alternator between the two machines, using potential regulators.

IV. RECTIFYING MACHINES OR PULSATING-CURRENT GENERATORS.

16. These include: Open-coil arc machines, constant-current rectifiers, constant-potential rectifiers.

The losses in open-coil arc machines are essentially the same as in sections 6 to 9 (closed-coil commutating machines). In alternating-current rectifiers, however, the output must be measured by wattmeter and not by voltmeter and ammeter, since owing to the pulsation of current and E. M. F., a considerable discrepancy may exist between watts and volt-amperes, amounting to as much as 10 or 15%.

17. In constant-current rectifiers, transforming from constant-potential alternating to constant direct current by means of constant-current transformers and rectifying commutators, the losses in the transformers are to be included in the efficiency and have to be measured when operating the rectifier, since in this case the losses are generally greater than when feeding an alternating secondary circuit. In constant-current transformers the load losses are usually larger than in constant-potential transformers and thus should not be neglected.

The most satisfactory method of determining the efficiency in rectifiers is to measure electric input and electric output by wattmeter. The input is usually not non-inductive, owing to a considerable phase displacement and to wave distortion. For this reason the apparent efficiency should also be considered, since it is usually much lower than the true efficiency. The power consumed by the synchronous motor or other source driving the rectifier should be included in the electric input.

V. STATIONARY INDUCTION APPARATUS.

18. Since the efficiency of induction apparatus depends upon the wave shape of E. M. F., it should be referred to a sine wave of E. M. F., except where expressly specified otherwise. The efficiency should be measured with non-inductive load, and at rated frequency, except where expressly specified otherwise. The losses are:

a. Molecular magnetic friction and eddy currents measured at open circuit and at rated voltage — I r, where I = rated current, r = resistance of primary circuit.

b. Resistance losses, the sum of the $I^2\ r$ of primary and of secondary in a transformer, or of the two sections of the coil in the compensator or auto-transformer, where I = current in the coil or section of coil, r = resistance.

c. Load losses; i. e., eddy currents in the iron and especially in the copper conductors, caused by the current. They should be measured by short-circuiting the secondary of the transformer and impressing upon the primary an E. M. F. sufficient to send full-load current through the transformer. The loss in the transformer under these conditions measured by wattmeter gives the load losses $+ I^2\ r$ losses in both primary and secondary coils.

d. Losses due to the methods of cooling, as power consumed by the blower in air-blast transformers, and power consumed by the motor driving pumps in oil or water-cooled transformers. Where the same cooling apparatus supplies a number of transformers, or is installed to supply future additions, allowance should be made therefor.

19. In potential regulators the efficiency should be taken at the maximum voltage for which the apparatus is designed and with non-inductive load, unless otherwise specified.

VI. ROTARY INDUCTION APPARATUS.

20. Owing to the existence of load losses and since the magnetic density in the induction motor under load changes in a complex manner, the efficiency should be determined by measuring the electric input by wattmeter and the mechanical output at the pulley, gear, coupling, etc.

21. The efficiency should be determined at the rated frequency and the input measured with sine waves of impressed E. M. F.

22. The efficiency may be calculated from the apparent input, the power factor, and the power output. The same applies to induction generators. Since phase displacement is inherent in induction machines, their apparent efficiency is also important.

23. In frequency changes; i. e., apparatus transforming from a polyphase system to an alternating system of different frequency, with or without a change in the number of phases, and phase converters; i. e., apparatus converting from an alternating system, usually single phase, to another alternating system, usually polyphase, of the same frequency, the efficiency should also be determined by measuring both output and input.

VII. TRANSMISSION LINES.

24. The efficiency of transmission lines should be measured with non-inductive load at the receiving end, with the rated receiving pressure and frequency, also with sinusoidal impressed E. M. F.'S., except where expressly specified otherwise, and with the exclusion of transformers or other apparatus at the ends of the line.

RISE OF TEMPERATURE.

GENERAL PRINCIPLES.

25. Under regular service conditions, the temperature of electrical machinery should never be allowed to remain at a point at which permanent deterioration of its insulating material takes place.

26. The rise of temperature should be referred to the standard conditions of a room-temperature of 25° C., a barometric pressure of 760 mm. and normal conditions of ventilation; that is, the apparatus under test should neither be exposed to draft, nor enclosed, except where expressly specified.

27. If the room temperature during the test differs from 25° C. the observed rise of temperature should be corrected by ½% for each degree C*. Thus, with a room temperature of 35° C., the observed rise of temperature has to be decreased by 5%, and with a room temperature of 15° C., the observed rise of temperature has to be increased by 5%. The thermometer indicating the room temperature should be screened from thermal radiation emitted by heated bodies, or from drafts of air. When it is impracticable to secure normal conditions of ventilation on account of an adjacent engine, or other sources of heat, the thermometer for measuring the air temperature should be placed so as fairly to indicate the temperature which the machine would have if it were idle, in order that the rise of temperature determined shall be that caused by the operation of the machine.

28. The temperature should be measured after a run of sufficient duration to reach practical constancy. This is usually from 6 to 18 hours, according to the size and construction of the apparatus. It is permissible, however, to shorten the time of the test by running a lesser time on an overload in current and voltage, then reducing the load to normal, and maintaining it thus until the temperature has become constant.

In apparatus intended for intermittent service, as railway motors, starting rheostats, etc., the rise of temperature should be measured after a shorter time, depending upon the nature of the service, and should be specified.

*This correction is also intended to compensate, as nearly as is at present practicable, for the error involved in the assumption of a constant temperature coefficient of resistivity; i. e., 0.4% per deg. C. taken with varying initial temperature.

In apparatus which by the nature of their service may be exposed to overload, as railway converters, and in very high voltage circuits, a smaller rise of temper ture should be specified than in apparatus not liable to overloads or in low-voltage apparatus. In apparatus built for conditions of limited space, as railway motors, a higher rise of temperature must be allowed.

29. In electrical conductors, the rise of temperature should be determined by their increase of resistance. For this purpose the resistance may be measured either by galvanometer test, or by drop-of-potential method. A temperature coefficient of 0.4% per degree C., may be assumed for copper.[a] Temperature elevations measured in this way are usually in excess of temperature elevations measured by thermometers.

30. It is recommended that the following maximum values of temperature elevation should not be exceeded:

Commutating machines, rectifying machines, and synchronous machines.
- Field and armature, by resistance, 50° C.
- Commutator and collector rings and brushes, by thermometer, 55° C.
- Bearings and other parts of machine, by thermometer, 40° C.

Rotary induction apparatus:
- Electric circuits, 50° C., by resistance.
- Bearings and other parts of the machine 40° C., by thermometer.

In squirrel cage or short-circuited armatures, 55° C., by thermometer, may be allowed.

Transformers for continuous service—electric circuits by resistance 50° C., other parts by thermometer, 40° C., under conditions of normal ventilation.

Reactive coils, induction and magneto regulators—electric circuits by resistance 55° C., other parts by thermometer, 45° C.

Where a thermometer, applied to a coil or winding, indicates a higher temperature elevation than that shown by resistance measurement, the thermometer indication should be accepted. In using the thermometer, care should be taken so to protect its bulb as to prevent radiation from it, and, at the same time, not to interfere seriously with the normal radiation from the part to which it is applied.

31. In the case of apparatus intended for intermittent service, the temperature elevation which is attained at the end of the period corresponding to the term of full load, should not exceed 50° C. by resistance in electric circuits. In the case of transformers intended for intermittent service, or not operating continuously at full load, but continuously in circuit, as in the ordinary case of lighting transformers, the temperature elevation above the surrounding air-temperature should not exceed 50° C. by resistance in electric circuits and 40° C. by thermometer in other parts, after the period corresponding to the term of full load. In this instance, the test load should not be applied until the transformer has been in circuit for a sufficient time to attain the temperature elevation due to core loss. With transformers for commercial lighting, the duration of the full-load test may be taken as three hours, unless otherwise specified. In the case of railway, crane, and elevator motors, the conditions of service are necessarily so varied that no specific period corresponding to the full-load term can be stated.

INSULATION.

32. The ohmic resistance of the insulation is of secondary importance only, as compared with the dielectric strength, or resistance to rupture by high voltage.

Since the ohmic resistance of the insulation can be very greatly increased by baking, but the dielectric strength is liable to be weakened thereby, it is preferable to specify a high dielectric strength rather than a high insulation resistance. The high voltage test for dielectric strength should always be applied.

INSULATION RESISTANCE.

33. Insulation resistance tests should, if possible, be made at the pressure for which the apparatus is designed.

The insulation resistance of the complete apparatus must be such that the rated voltage of the apparatus will not send more than $\frac{1}{1{,}000{,}000}$ of the full load current, at the rated terminal voltage, through the insulation. Where the load value in this way exceeds 1 megohm, 1 megohm is sufficient.

DIELECTRIC STRENGTH.

34. The dielectric strength or resistance to rupture should be determined by a continued application of an alternating E. M. F. for one minute. The source of alternating E. M. F. should be a transformer of such size that the charging current of the apparatus as a condenser does not exceed 25% of the rated capacity of the transformer.

35. The high voltage tests should not be applied when the insulation is low, owing to dirt or moisture, and should be applied before the machine is put into commercial service.

36. It should be pointed out that tests at high-voltages considerably in excess of the normal voltages are admissible on new machines, to determine whether they fulfill their specifications,, but should not be made subsequently at a voltage much exceeding the normal, as the actual insulation of the machine may be weakened by such tests.

37. The test for dielectric strength should be made with the completely assembled apparatus and not with its individual parts, and the voltage should be applied as follows:

1st. Between electric circuits and surrounding conducting material, and,

2d. Between adjacent electric circuits, where such exist, as in transformers.

The tests should be made with a sine wave of E. M. F., or where this is not available, at a voltage giving the same striking distance between needle points in air, as a sine wave of the specified E. M. F., except where expressly specified otherwise. As needles, new sewing needles should be used. It is recommended to shunt the apparatus during the test by a spark gap of needle points set for a voltage exceeding the required voltage by 10%.

A table of approximate sparking distances is given in Appendix V.

38. The following voltages are recommended for apparatus not including transmission lines or switchboards:

[a]By the formula $R(T) = Rt\ (1 + 0.004\ \phi)$. Where Rt is the resistance at room temperature, R(T) the resistance when heated, and ϕ the temperature elevation (T-t) in degrees centigrade.

Rated terminal voltage.	Testing voltage.
Not exceeding 400 volts*	1,000 volts.
" " 400 " †	1,500 "
400 and over, but less than 800 volts*	1,500 "
400 " " " " 800 " †	2,000 "
800 " " " " 1,200 " ‡	3,500 "
1,200 " " " " 2,500 " ‡	5,000 "
2,500 " " ‡	§
Synchronous motor fields and fields of converters started from the alternating current side	5,000 "

*Capacity, under 10 K-W. †10 K-W. and over. ‡Any. §Double the normal rated voltages.

Alternator field circuits should be tested under a breakdown test voltage corresponding to the rated voltage of the exciter, and referred to an output equal to the output of the alternator; i. e., the exciter should be rated for this test as having an output equal to that of the machine it excites.

Condensers should be tested at twice their rated voltage and at their rated frequency.

The values in the table above, are effective values, or square roots of mean square, reduced to a sine wave of E. M. F.

39. In testing insulation between different electric circuits as between primary and secondary of transformers, the testing voltage must be chosen corresponding to the high-voltage circuit.

40. In transformers of from 10,000 volts to 20,000 volts, it should be considered as sufficient to operate the transformers at twice its rated voltage, by connecting first the one, and then the other terminal of the high-voltage winding to the core and to the low-voltage winding. The test of dielectric resistance between the low-voltage winding and the core should be in accordance with the recommendation in Section 38, for similar voltages and capacities.

41. When machines or apparatus are to be operated in series, so as to employ the sum of their separate E. M. F's., the voltage should be referred to this sum, except where the frames of the machines are separately insulated both from ground and from each other.

REGULATION.

42. The term regulation should have the same meaning as the term "inherent regulation," at present frequently used.

43. The regulation of an apparatus intended for the generation of constant potential, constant current, constant speed, etc., is to be measured by the maximum variation of potential, current, speed, etc., occurring within the range from full load to no load, under such constant conditions of operation as give the required full-load values.

If the manner in which the variation in potential, current, speed, etc., between full load and no load is not specified, it should be assumed to be a simple linear relation; i. e., undergoing uniform variation between full load and no load.

The regulation of an apparatus may, therefore, differ according to its qualification for use. Thus the regulation of a compound-wound generator specified as a constant-potential generator, will be different from that it possesses when specified as an over-compounded generator.

45. The regulation is given in percentage of the full-load value of potential, current, speed, etc., and the apparatus should be steadily operated during the test under the same conditions as at full load.

46. The regulation of generators is to be determined at constant speed; of alternating apparatus at constant impressed frequency.

47. The regulation of a generator-unit, consisting of a generator united with a prime-mover, should be determined at constant conditions of the prime mover; i. e., constant steam pressure, head, etc. It would include the inherent speed variations of the prime mover. For this reason the regulation of a generator-unit is to be distinguished from the regulation of either the prime-mover or of the generator contained in it, when taken separately.

48. In apparatus generating, transforming or transmitting alternating currents, regulation should be understood to refer to non-inductive load, that is a load in which the current is in phase with the E. M. F. at the output side of the apparatus, except where expressly specified otherwise.

49. In alternating apparatus receiving electric power, regulation should refer to a sine wave of E. M. F., except where expressly specified otherwise.

50. In commutating machines, rectifying machines and synchronous machines, as direct-current generators and motors, alternating-current and polyphase generators, the regulation is to be determined under the following conditions:

a. At constant excitation in separately excited fields.

b. With constant resistance in shunt field circuits, and

c. With constant resistance shunting series fields; i. e., the field adjustment should remain constant, and should be so chosen as to give the required full-load voltage at full-load current.

51. In constant-potential machines, the regulation is the ratio of the maximum difference of terminal voltage from the rated full-load value (occurring within the range from full load to open circuit), to the full load terminal voltage.

52. In constant-current machines, the regulation is the ratio of the maximum difference of current from the rated full-load value (occurring within the range from full-load to short circuit), to the full-load current.

53. In constant-power machines, the regulation is the ratio of maximum difference of power from the rated full-load value (occurring within the range of operation specified) to the rated power.

54. In over-compounded machines, the regulation is the ratio of the maximum difference in voltage from a straight line connecting the no-load and full-load values of terminal voltage as function of the current, to the full-load terminal voltage.

55. In constant-speed continuous-current motors, the regulation is the ratio of the maximum variation of speed from its full-load value (occurring within the range from full-load to no-load) to the full-load speed.

56. In transformers, the regulation is the ratio of the rise of secondary terminal voltage from full-load to no-load (at constant primary impressed terminal voltage) to the secondary terminal voltage.

57. In induction motors, the regulation is the ratio of the rise of speed from full-load to no-load (at constant impressed voltage) to the full-load speed.

The regulation of an induction motor is, therefore, not identical with the slip of the motor, which is the ratio of the drop in speed from synchronism to the synchronous speed.

58. In converters, dynamotors, motor-generators, and frequency changers, the regulation is the ratio of the maximum difference of terminal voltage at the output side from the rated full-load voltage (at constant impressed voltage and at constant frequency) to the full-load voltage on the output side.

59. In transmission lines, feeders, etc., the regulation is the ratio of maximum voltage difference at the receiving end, between no-load and full non-inductive load, to the full-load voltage at the receiving end, with constant voltage impressed upon the sending end.

60. In steam engines, the regulation is the ratio of the maximum variation of speed in passing from full-load to no-load (at constant steam pressure at the throttle) to the full-load speed.

61. In a turbine or other water-motor, the regulation is the ratio of the maximum variation of speed from full-load to no-load (at constant head of water; i. e., at constant difference of level between tail race and head race), to the full-load speed.

VARIATION AND PULSATION.

62. In prime movers which do not give an absolutely uniform rate of rotation or speed, as in steam engines, the "variation" is the maximum angular displacement in position of the revolving member expressed in degrees, from the position it would occupy with uniform rotation, and with one revolution as 360°; and the pulsation is the ratio of the maximum change of speed in an engine cycle to the average speed.

63. In alternators or alternating-current circuits in general, the variation is the maximum difference in phase of the generated wave of E. M. F. from a wave of absolutely constant frequency, expressed in degrees, and is due to the variation of the prime mover. The pulsation is the ratio of the maximum change of frequency during an engine cycle to the average frequency.

64. If n = number of poles, the variation of an alternator is $\frac{n}{2}$ times the variation of its prime mover if direct connected, and $\frac{n}{2}$ p times the variation of the prime mover if rigidly connected thereto in the velocity ratio p.

65. The pulsation of an alternating-current circuit is the same as the pulsation of the prime mover of its alternator.

RATING.

66. Both electrical and mechanical power should be expressed in kilo-watts, except when otherwise specified. Alternating-current apparatus should be rated in kilow tts on the basis of non-inductive condition; i. e., with the current in phase with the terminal voltage.

67. Thus the electric power generated by an alternating-current apparatus equals its rating only at non-inductive load, that is when the current is in phase with the terminal voltage.

68. Apparent power should be expressed in kilovolt-amperes as distinguished from real power in kilo-watts.

69. If a power factor other than 100% is specified, the rating should be expressed in kilovolt-amperes and power-factor, at full load.

70. The full-load current of an electric generator is that current which with the rated full-load terminal voltage gives the rated kilowatts, but in alternating-current apparatus only at non-inductive load.

71. Thus in machines in which the full-load voltage differs from the no-load voltage, the full-load current should refer to the former.

If P = rating of an electric generator and E = full-load terminal voltage, the full-load current is:

$I = \frac{P}{E}$ in a continuous-current machine or single-phase alternator.

$I = \frac{P}{E\sqrt{3}}$ in a three-phase alternator.

$I = \frac{P}{2E}$ in a quarter-phase alternator.

72. Constant-current machines, such as series arc-light generators, should be rated in kilowatts based on terminal volts and amperes at full load.

73. The rating of a fuse or circuit breaker should be the current-strength at which it will open the circuit, and not the working-current strength.

CLASSIFICATION OF VOLTAGES AND FREQUENCIES.

74. In direct-current, low-tension generators, the following average terminal voltages are in general use and are recommended:

125 volts. 250 volts. 550 volts.

75. In direct-current, and alternating-current, low-pressure circuits, the following average terminal voltages are in general use and are recommended:

110 volts. 220 volts.

In direct-current power circuits, for railway and other service, 500 volts may be considered as standard.

76. In alternating-current, high-pressure circuits at the receiving end, the following pressures are in general use and are recommended:

1,000 volts. 2,000 volts. 3,000 volts. 6,000 volts. 10,000 volts. 15,000 volts. 20,000 volts.

77. In alternating-current high-pressure generators, or generating systems, the following terminal voltages are in general use and are recommended:

1,150 volts. 2,300 volts. 3,450 volts.

These pressures allow of a maximum drop in transmission of 15% of the pressure at the receiving end. If the drop required is greater than 15%, the generator should be considered as special.

78. In alternating-current circuits, the following approximate frequencies are recommended as desirable:

25 or 30 cycles. 40 cycles. 60 cycles. 120 cycles.*

These frequencies are already in extensive use and it is deemed advisable to adhere to them as closely as possible.

OVERLOAD CAPACITIES.

79. All guarantees on heating, regulation, sparking, etc., should apply to the rated load, except where expressly specified otherwise, and in alternating-current apparatus to the circuit in phase with the terminal E. M. F., except where a phase displacement is inherent in the apparatus.

*The frequency of 120 cycles may be considered as covering the already existing commercial frequencies between 120 cycles and 140 cycles, and the frequency of 60 cycles as covering the already existing commercial frequencies between 60 cycles and 70 cycles.

80. All apparatus should be able to carry a reasonable overload without self-destruction by heating, sparking, mechanical weakness, etc., and with an increase of temperature elevation not exceeding 15° C., above those specified for full loads. See Secs. 25 to 31.

81. Overload guarantees should refer to normal conditions of operation regarding speed, frequency, voltage, etc., and to non-inductive conditions in alternating apparatus, except where a phase displacement is inherent in the apparatus.

82. The following overload capacities are recommended:

1st. In direct-current generators and alternating-current generators; 25% for one-half hour.

2d. In direct-current motors and synchronous motors, 25% for one-half hour, 50% for one minute; except in railway motors and other apparatus intended for intermittent service.

3d. Induction motors. 25% for one-half hour, 50% for one minute.

4th. Synchronous converters. 50% for one-half hour.

5th. Transformers. 25% for one-half hour. Except in transformers connected to apparatus for which a different overload is guaranteed, in which case the same guarantees shall apply for the transformers as for the apparatus connected thereto.

6th. Exciters of alternators and other synchronous machines, 10% more overload than is required for the excitation of the synchronous machine at its guaranteed overload, and for the same period of time.

APPENDIX—EFFICIENCY.

I. EFFICIENCY OF PHASE-DISPLACING APPARATUS.

In apparatus producing phase displacement, as, for example, synchronous compensators, exciters of induction generators, reactive coils, condensers, polarization cells, etc., the efficiency should be understood to be the ratio of the volt-ampere activity to the volt-ampere activity plus power loss.

The efficiency may be calculated by determining the losses individually, adding to them the volt-ampere activity, and then dividing the volt-ampere activity by the sum.

1st. In synchronous compensators and exciters of induction generators, the determination of losses is the same as in other synchronous machines under Sections 10 and 11.

2d. In reactive coils the losses are molecular friction, eddy losses, and I^2r loss. They should be measured by wattmeter. The efficiency of reactive coils should be determined with a sine wave of impressed E. M. F., except where expressly specified otherwise.

3d. In condensers, the losses are due to dielectric hysteresis and leakage and should be determined by wattmeter with a sine wave of E. M. F.

4th. In polarization cells, the losses are those due to electric resistivity and a loss in the electrolyte of the nature of chemical hysteresis and are usually very considerable. They depend upon the frequency, voltage and temperature, and should be determined with a sine wave of impressed E. M. F., except where expressly specified otherwise.

II. APPARENT EFFICIENCY.

In apparatus in which a phase displacement is inherent to their operation, apparent efficiency should be understood as the ratio of net power output to volt-ampere input.

Such apparatus comprise induction motors, reactive synchronous converters, synchronous converters controlling the voltage of an alternating current system, self-exciting synchronous motors, potential regulators, and open magnetic circuit transformers, etc.

Since the apparent efficiency of apparatus generating electric power depends upon the power factor of the load, the apparent efficiency, unless otherwise specified, should be referred to a load power-factor of unity.

III. POWER FACTOR AND INDUCTANCE FACTOR.

The power factor in alternating circuits or apparatus may be defined as the ratio of the electric power, in watts, to volt-amperes.

The inductance factor is to be considered as the ratio of wattless volt-amperes to total volt-amperes.

Thus, if p = power factor, q = inductance factor, then

$$p^2 + q^2 = 1.$$

The power factor is the

$$\frac{\text{(energy component of current or E. M. F.)}}{\text{(total current or E. M. F.)}} = \frac{\text{true power.}}{\text{volt amperes.}}$$

and the inductance factor is the

$$\frac{\text{(wattless component of current or E.M.F.)}}{\text{(total current or E. M. F.)}}$$

Since the power-factor of apparatus supplying electric power depends upon the power-factor of the load, the power-factor of the load should be considered as unity, unless otherwise specified.

IV. NOTATION.—The following notation is recommended:

E e, voltage, E. M. F., potential difference.
I, i, current.
P, power.
Φ, magnetic flux.
β, magnetic density.
R, r, resistance.
X, x, reactance.
Z, z, impedance.
L, l, inductance.
C, c, capacity.

Vector quantities when used should be denoted by capital italics.

V. SPARKING DISTANCES.—Table of Sparking Distances in Air between Opposed Sharp Needle-Points, for Various Effective Sinusoidal Voltages, in inches and in centimeters.

Kilovolts sq. root of mean square.	Distance, ins.	cms.	Kilovolts sq. root of mean square.	Distance, ins.	cms.
5	0.225	0.57	60	4.65	11.8
10	0.47	1.19	70	5.85	14.9
15	0.725	1.84	80	7.1	18.0
20	1.0	2.54	90	8.35	21.2
25	1.3	3.3	100	9.6	24.4
30	1.625	4.1	110	10.75	27.3
35	2.0	5.1	120	11.85	30.1
40	2.45	6.2	130	12.95	32.9
45	2.95	7.5	140	13.95	35.4
50	3.55	9.0	150	15.0	38.1